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S. HRG. 103-93

STATUS OF EFFORTS TO DEVELOP A CLEAN CAR

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HEARING

BEFORE THE

SUBCOMMITTEE ON
CLEAN AIR AND NUCLEAR REGULATION
OF THE

COMMITTEE ON
ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

APRIL 27, 1993

Printed for the use of the Committee on Environment and Public Works

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STATUS OF EFFORTS TO DEVELOP A CLEAN CAR

TUESDAY, APRIL 27, 1993

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR REGULATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:35 a.m. in room SD-406, Dirksen Senate Office Building, Hon. Joseph Lieberman [chairman of the subcommittee] presiding.

Present: Senators Lieberman, Kempthorne, and Reid.

OPENING STATEMENT OF HON. JOSEPH I. LIEBERMAN, U.S. SENATOR FROM THE STATE OF CONNECTICUT

Senator LIEBERMAN. Good morning and welcome to all.

This is the first in a series of hearings this subcommittee will do on the efforts to develop a cleaner or totally clean car in the United States. The health of both our economy and our environment, in large part, depends on the fate of the automobile, how it is built, how it operates, and what we do with it when it is junked.

Obviously, the economic well-being of the auto industry is vital to the hundreds of thousands of people directly employed in the automobile industry. What may not be so readily apparent is that the health of the automobile industry also affects the well-being of just about every sector of our economy.

For instance, the car industry accounts for nearly 10 percent of the wages paid to U.S. manufacturing workers. Also automobile production consumes about one-sixth of the output of the iron and steel industry and one-eighth of the output of a range of other industries, including textiles and service machine production.

So when Ford and General Motors layoff 80,000 workers, as they did between 1989 and 1991, and the big three, as a whole, lost $14 billion in domestic auto and truck markets in 1990 and 1991, we know that the pain is felt well beyond Detroit city limits.

In terms of the auto's environmental impact, the facts are also clear and impressive. Cars and trucks generate more ozone-creating pollutants than any other single source—50 percent in the case of the volatile organic emissions and 43 percent in the case of oxides of nitrogen. When it comes to carbon monoxide, motor vehicles are even bigger offenders, contributing more than 90 percent of the CO emissions in most urban areas.

In all, the transportation sector is responsible for 32 percent of all carbon dioxide emissions in the United States. Cars and trucks

account for 77 percent of that total. The widespread release of these gases, particularly carbon dioxide, is a major contributor to global climate change. Consequently, if we are to meet the goal set out last week by President Clinton to stabilize America's greenhouse gas emissions at 1990 levels by the year 2000, we must continue to pay even closer attention to the automobile as a source of pollution.

Overseeing implementation of the Clean Air Act is my own top priority as chairman of this subcommittee for this session, overseeing the implementation in its various forms. In many regions of our country, particularly the northeast and California, industrial sources of emissions have already been strictly controlled and States are in the process now of implementing further restrictions.

Many States have concluded that the only way they can meet the Act's deadlines is with low or, in some cases, even zero emission cars which achieve emission levels below the mandates of the Clean Air Act.

To help the States make this scenario a reality, President Clinton earlier this year established a Clean Car Task Force designed to coordinate efforts in research and development between the public and private sectors. I think this was a step in the right direction and I certainly agree that it's time to establish a partnership between American automakers and the American Government to alleviate the environmental problems associated with the automobile and at the same time, to restore the technological preeminence of our Nation's automobile industry which, of course, will also help reestablish its marketing preeminence. For the good of the environment and for the sake of America's competitive position in the global market, we've got to quickly develop the green cars of the future.

As we're going to hear today from one of our witnesses, Michael Walsh, it is highly likely that those automakers who produce the cleanest cars will also sell the most cars in the future. We already know that the nations throughout the world are rapidly mandating cleaner cars.

For example, in 1990, approximately 40 percent of new cars were equipped with a catalyst. In 1993, that figure rose to approximately 75 to 80 percent. In the European Community, the largest automobile market in the world today, Germany, is proposing that the EC adopt standards for the year 2000 that would be roughly equivalent to California's toughest emission standards. If those standards are accepted, the manufacturers who can meet them most quickly and least expensively will control that enormous European market.

In this country, meanwhile, automakers have been spending too much of their time in court and local legislators have been fighting other States from adopting California standards. Court victories in those cases I think would only be pyrrhic ones because they would likely stand in the way of United States automakers increasing their competitiveness in the global market. The money that carmakers are spending on lawyers and lobbyists would be much better spent, in my opinion, on scientists and engineers.

Nevertheless, I'm optimistic that the auto industry's participation in the Clean Car Task Force is the start of a more forward-looking approach to the car pollution debate. I hope that they and

all of us will heed the President's clarion call on Earth Day for "American ingenuity to produce the best and most energy efficient technology."

I look forward to hearing from our expert witnesses today who bring a truly wide range of knowledge to us about automobile technology. Included in the information they will present before us is evidence that defense contractors may be particularly well-qualified to develop clean car technologies. Coming from Connecticut, a defense-dependent State, that is hopeful news.

I should note for the record that in Connecticut, a subsidiary of Pratt & Whitney, which is know for jet engine manufacturing, a subsidiary known as International Fuel Cells, has become a leader in the development of fuel cell technology.

So in the coming months, this subcommittee will be closely following the work of the Clean Car Task Force and we hope in succeeding hearings to hear from the Director of the Office of Science and Technology Policy and the representatives of the automakers about the work of the task force.

I would now yield for an opening statement to my colleague, Senator Kempthorne.

OPENING STATEMENT OF HON. DIRK KEMPTHORNE, U.S. SENATOR FROM THE STATE OF IDAHO

Senator KEMPTHORNE. Mr. Chairman, thank you very much.

Like you, Mr. Chairman, I look forward to hearing the discussion this morning about the technology that has been developed thus far. I have a great deal of confidence in American technology and innovation. I think innovation is something that is going to allow us to meet some of the challenges that we're facing in the energy field.

One key goal of any American policy, I think can be underscored by a single word and that is efficiency. So we will be looking for the efficient use of energy in meeting our transportation needs. The important challenges to America in management of our energy needs is underscored also by how we balance our needs against our desire for an environmentally sound future.

Mr. Chairman, I just join you in looking forward to the discussion by our distinguished panel and then participating in questions to some of the members of than panel.

Thank you.

Senator LIEBERMAN. Thank you very much, Senator.

We will start with Michael Walsh who has been before the committee before. Michael is a consultant from Arlington, Virginia. You can more specifically describe yourself if you like, Michael.

We're going to operate the timer on a seven-minute cycle. If you can keep your remarks within that amount, that's great. If you feel constrained by it, exercise your First Amendment liberties a little beyond but please don't do so without limitation.

Michael, good morning.

STATEMENT OF MICHAEL WALSH, CONSULTANT

Mr. WALSH. Good morning, Mr. Chairman.

My name is Mike Walsh, as you indicated. I'm an independent technical consultant in the motor vehicle pollution control field and was very involved with this committee throughout the development of the Clean Air Act amendments of 1990.

In my testimony today, and with the help of Mike Henderson, I have a few charts. Could you put the first one up, Michael?

In my testimony today, I'd like to emphasize two key points, Mr. Chairman. One is that the future continued growth in the global automobile industry is dependent on its ability to build clean, efficient vehicles, and, second, those companies that will be most successful in meeting the market demand in the future will be those that produce highly efficient and clean vehicles.

Senator LIEBERMAN. Mike, I don't want to interrupt you but just for the record, I know from your previous work before the committee, just to qualify you in this regard, you have done a lot of consulting abroad on clean air questions?

Mr. WALSH. That's correct. I'm currently involved, as indicate in my statement, in projects in Sri Lanka, in Manila, in Bangkok, in China and have done work for both the World Bank and the United Nations and many countries around the world.

Across the entire globe, motor vehicle usage has increased tremendously as this figure indicates. In 1950, there were only about 53 million cars on the world's highways and here we are four decades later with the global automobile fleet exceeding 430 million vehicles, more than an eightfold increase.

On average, the fleet has grown by about 9.5 million vehicles per year over this period. While the growth rate has slowed in the highly industrialized countries of the world, population growth and increased urbanization and industrialization are accelerating the use of motor vehicles elsewhere.

Overall growth in the production of motor vehicles, especially since the end of World War II, has been equally dramatic. Between 1950 and 1990, production increased almost linearly, as you can see from that top line, from about 10 million vehicles per year to now about 50 million vehicles per year, approximately 1 million additional vehicles are produced each year compared to the year before over this period of time.

Over the past several decades, motor vehicle production has gradually expanded from one region of the world to another. Initially, and through the 1950's, it was dominated by North America. The first wave of competition came from Europe and by the late 1960's, European production had surpassed that of the United States. Over the past two decades, the car industry in Asia led by Japan has grown rapidly and now rivals those in both the United States and Europe.

The downward trend in the U.S. share of the global marketplace continues unabated to this day and may actually be worsening. You can see from this figure the top line shows the U.S. company share of the world marketplace declining while the European and Japanese industry continue to increase.

Senator LIEBERMAN. Mike, I understand our proportion of the market is going down but we're actually producing less total cars?

Mr. WALSH. Oh, no.

Senator LIEBERMAN. I misread the earlier chart?

Mr. WALSH. Right.

Senator LIEBERMAN. It's just that our percentage of the marketplace is down?

Mr. WALSH. Our percentage of the marketplace is declining, that's correct, Senator.

Senator LIEBERMAN. Because the market is growing so dramatically?

Mr. WALSH. That's correct.

One result of the growth in vehicles and their production as you indicated in your opening statement, Senator, is that worldwide cars, trucks, buses and other motor vehicles are playing an ever increasingly important role in global climate change and air pollution.

As large oil consumers, motor vehicles are major sources of carbon dioxide, VOCs, nitrogen oxides, the precursors in the latter cases to both tropospheric ozone and acid raid, carbon monoxide and even chlorofluorocarbons. Motor vehicles are also the major source of toxic compounds in most of our urban areas.

Virtually the entire motor vehicle fleet runs on fossil fuels, primarily oil, and for every 15 gallon fill-up at a service station, about 300 pounds of carbon dioxide are eventually released into the atmosphere. Globally, motor vehicles account for about a third of the world's oil consumption and about 14 percent of the world's carbon dioxide emissions from fossil fuel burning. For the United States, motor vehicles cause about 50 percent of oil demand and about 25 percent of our carbon dioxide emissions.

Widespread and pervasive smog, which comes from the hydrocarbons and the NO_x from vehicles, will be a long-term problems in many areas of the world unless more stringent controls on vehicles and other sources are adopted. Areas of rapid industrialization are now starting to note similar air pollution problems to those of the industrialized world.

You can go through the litany of cities—Mexico, Delhi, Seoul, Singapore, Hong Kong, Sao Paolo, Manila, Santiago, Bangkok, Taipei, Bejing—all of which I have personal experience with, are already in most cases experiencing very severe air pollution problems. Some of these cities, especially Bangkok, Athens, Mexico City, stand out as really being in a crisis with regard to air pollution today.

As the vehicle population has grown and become increasingly concentrated in the world's growing number of megacities, the number of people subjected to unhealthy levels of pollution continues to rise.

Fortunately, advances in automotive technologies have made it possible for countries to respond to these health and environmental concerns by dramatically lowering emissions from motor vehicles and increasingly, countries around the world are taking advantage of them. Initial crankcase hydrocarbon controls were introduced in the early 1960's, followed by exhaust—carbon monoxide and hydrocarbon—standards later that decade. During the mid to late 1970's, advanced technologies, including catalytic converters were introduced on most new cars in the United States and Japan.

These technologies resulted from a conscious decision by the Congress to force the development of new approaches and dramatically

reduced CO, HC and NO_x emissions beyond previous systems. As illustrated in this figure, at the same time that pollution levels were being reduced, the line to the left, vehicle fuel efficiency doubled. So the industry today I think can take great pride in the fact that new cars produced in the United States emit but a small fraction of the pollution they did a generation ago for each mile they drive and consume only half the volume of fuel.

With knowledge of these technological developments spreading and the adverse effects of vehicle pollution becoming increasing apparent in many parts of the world, more and more people are demanding the use of these same types of technology in their countries.

Focusing for a second on southeast Asia, which is the most rapidly growing vehicle market in the world today, you can see that building on Japan, which was one of the first countries to adopt tight standards, we now have catalyst-based emission standards in effect in South Korea, in Taiwan, in Hong Kong, Singapore and since the first of this year, in Bangkok in Thailand. I expect within the next couple of years this will spread to Malaysia and Indonesia, the dark shaded areas there.

In fact, if we look at the world as a whole, as you indicated, Mr. Chairman, in your opening statement, we now can see that approximately 75 to 80 percent of the vehicles produced this year around the world will have today's state-of-the-art vehicle technology on them, very dramatic progress.

Just as the world as been moving toward catching up with the United States in adopting tight emission standards, the U.S. and California during 1990 decided to push technology toward the next generation of controls. As California standards are more stringent than Federal requirements, in this chart, the line across the top is the current U.S. emission standard for the oxides of nitrogen; the declining line is what resulted from the Clean Air Act amendments of 1990; and the bottom line is the California standards as they currently exist and as they will be tightened throughout the rest of the decade.

As California standards are much more stringent than Federal requirements and mandate the development of zero emission vehicles, many other States with serious air pollution problems have decided to opt into the California program as well.

On a technological level, the response to California's requirements has been tremendous. For example, just about a year ago on April 14, 1992, Ford Motor Company announced that a 1993 model Ford Escort and Mercury Tracer powered by a new 1.9 liter engine which they developed, "achieved a major milestone four years ahead of schedule making it the first automaker to meet the first in a series of very stringent air quality standards adopted by California for the 1990's." As Ford further noted, "The engine in these vehicles was designed and is manufactured in the United States using U.S. components." Clearly, the leadership is there.

EPA has also tested a two-stroke engine manufactured by Orbital Engine Company and found it to have exceptional fuel economy, while virtually achieving California's ultralow emission levels. In addition, as I think you'll hear from other members of the panel today, tremendous advances in electric vehicles and fuel cells are

starting to emerge in response to California's specific mandate for as much as 10 percent of their fleet to be zero emission vehicles by early in the next century.

Ironically, while technology continues to advance and the domestic car industry has publicly reacted very positively to President Clinton's green car initiative, they continue, as you pointed out in your statement, Mr. Chairman, to aggressively oppose the State efforts to adopt the California standards throughout especially the Northeast both in the courts and in the State legislatures, trying to repeal these efforts.

This is especially puzzling and troubling because the development of these clean vehicle technologies would tend, in my view, to give the domestic vehicle industry a leg up on the rest of the world as the rest of the world moves to these tighter emission standards.

This movement toward tighter standards is already beginning. As this figure indicates, Germany has already proposed that the European Community, which is the largest vehicle market in the world today, adopt standards similar to California's by the year 2000. You can't see it very well, but it's those little circles down in the lower righthand corner superimposed almost identically over the California emission requirements in that same time frame.

As I indicated, Europe today is the single largest vehicle market but it's a rapidly growing market as the European Community expands. We now have a number of what are called the EFTA countries—the Scandinavian countries, Austria and Switzerland—that formally applied for EC membership and four of them are on a fast track toward 1990 full membership in the Community. I guess we now have four, with the division of Czechoslovakia, countries that are now associate members of the Community from Eastern Europe. So in the aggregate, by about the turn of the century, you can see a much expanded European Community which will have a common set of very tight emission requirements.

In looking to the future vehicle marketplace, to come to conclusion, Mr. Chairman, two trends do stand out. First, it is expected that continuous high growth in vehicle production will remain the norm, at least for the next several decades, as countries with much lower per capita vehicle populations advance economically. The major threat to this growth in new vehicle sales, in my judgment, is the serious environmental problems which these vehicles cause.

In effect, therefore, the future of the automobile industry is very dependent on its ability to clean up these vehicles. Someone used the phrase the other day, "clean them or park them." If they can't clean them up, more and more cities especially will start to restrict the use of vehicles.

In addition, I think the second conclusion that emerges from this is that those companies which will be the most successful in cleaning up their vehicles and making them fuel efficient will be those that succeed in the future world marketplace. With European and other countries committed to stabilization of CO2 and the demand for more fuel efficient vehicles expanding in other parts of the world, this pressure will continue to increase. As the pollution problems become more severe in the rapidly developing countries where the high growth is taking place, they are increasingly moving toward stringent control of conventional pollutants.

If U.S. companies aggressively pursue this market, it will lead, of course, to more jobs and greater profitability for U.S. companies. Conversely, those which cannot or choose not to compete in this aspect of the market will fall further and further behind.

Thank you very much, Mr. Chairman and Senator.

Senator LIEBERMAN. Thank you, Michael for that excellent testimony.

We'll go now to Dr. Lloyd. Alan Lloyd is Chief Scientist with the South Coast Air Quality Management District in California. We look forward to hearing now about California's to move toward lower emission, indeed toward zero emission, vehicles.

Welcome. Thanks for coming.

STATEMENT OF ALAN LLOYD, CHIEF SCIENTIST, SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Mr. LLOYD. Good morning, Mr. Chairman and Senator Kempthorne.

Thank you for the opportunity to address this subcommittee.

As indicated, my name is Alan Lloyd. I'm responsible for the Planning and Technology Advancement Office of the South Coast Air Quality Management District. This is the agency responsible for protecting the public health in about a 13,000 square mile region, including Los Angeles, Orange, Riverside and the non-desert portion of San Bernardino Counties. We're impacted by the emissions from about 9 million vehicles.

Ever so often we go through an air quality management planning exercise in which we look at how we can obtain the Federal and State air quality standards. In doing that in 1991 and we're going through the same process now, we've had to admit that we cannot attain those standards basically without increasingly zero emission technology.

In terms of the air quality, the emissions from the automobile continue to be the major single source of pollution. However, we also acknowledge the substantial progress made by the auto industry. Now we have much lower polluting technologies, the cars drive much better and obviously have much greater fuel economy, as Mr. Walsh mentioned.

In spite of that, we still had to come up with the low emission vehicle clean fuel program from California. We were greatly encouraged by the President Clinton's technology initiative to focus basically on leapfrogging technology to the fuel cell and maybe other zero polluting technologies.

We are thoroughly committed to fuel cells. They are nonpolluting, quiet and more than twice as efficient as conventional engines. In fact, we're the founding member of the Ad Hoc Coalition on Fuel Cells for Transportation and have called for a national initiative on fuel cells for transportation maybe looking at about $4.4 billion to be committed by the year 2000 to provide this type of leapfrog in technology. That would include all transportation in contrast with the President's plan which was looking at the automobile. While this may sound like a lot of money, basically, it's only about one month's imported oil.

From my perspective of running a technology advancement program on about $7 million a year in a public-private partnership, I think I can provide the committee with some perspective on that and therefore, make some of the following suggestions.

It is most appropriate for the Government to share in the financial risk in this Advanced Technology Development Program. We understand that, I think it is very important this high risk technology. However, merely throwing dollars at the program is no guarantee of success. History has taught us that this is not a recipe for success. In fact, you must have full, private commitment to the same goal.

This program also must supplement and not replace existing efforts on California's Low Emission Vehicle, Clean Fuels Program. Auto companies both nationally and internationally have made unprecedented strides in reducing emissions following passage of the California legislation. Mr. Walsh beautifully demonstrated the progress we've made and I think Mr. Jack Smith will also provide examples using natural gas technology where, in fact, we're way ahead of schedule. So there is no reason to dilute ongoing efforts.

The Government is currently helping the auto industry through substantial support in the Advanced Battery Consortium and other programs. Any increase in these should not be at the expense of the proposed President's plan.

Current efforts are producing results. Technology forcing standards are working and are needed to clean up the air and protect public health. In fact, by the year 2000, all cars sold in California must meet a hydrocarbon standard that is half the Federal Tier 2 Standard.

Getting back to protecting public health, I state in my written testimony the air quality in southern California is causing health problems to the extent that the economic cost of that damage is roughly about $9 billion per year.

Senator LIEBERMAN. Nine billion dollars per year is estimated?

Mr. LLOYD. Nine billion dollars per year as a result of the adverse health impacts caused by pollution and most of that pollution comes from the automobile, about 60 percent or so.

The clean car initiative should be aimed at zero pollution. The President's visionary approach can help U.S. industry back to world leadership with increasing demand for their products worldwide. This will increase jobs and restore vitality to the auto industry. In fact, this is a major opportunity, as you indicated in your opening comments, for the diminishing U.S. defense and aerospace industries. This type of technological challenge, in fact, is really well-suited for the skills resident in that diminishing sector.

We had a visit last week from one of the major Japanese auto manufacturers. The Japanese auto industry is already deploying hundreds of engineers to meet market demands of zero emission cars. In fact, they are already looking ahead at what they term the second generation zero emission vehicle, which they look at as the fuel cell and maybe some other technologies.

While that's going on, we find that in fact the U.S. industry as well is working hard in many areas, as Mr. Walsh pointed out, basically trying, through legislation, to get those standards backed off.

Therefore, the proposed $1 billion in Federal funds should encourage the U.S. auto industry to do the same thing, that is to focus on the technological challenges and should not be used to fund the legal process to jeopardize the technologically feasible zero pollution technology.

In summary, what can you do? I think the members of your committee can help the process by supporting the California program. As demonstrated, that is feasible. Support those States wishing to adopt those programs. I think that is very important as we look worldwide, as Mr. Walsh pointed out. This will help to restore U.S. leadership and market. Continue to create an environment which fosters competition, not only competition with the major manufacturers but also as you're proposing to put Federal dollars, allow a mechanism for the entrepreneurs, the small business, to access those dollars and access that risk-sharing. That we see, with the advanced technology, as very important to allow not only the major manufacturers to have that opportunity, but also the entrepreneurs.

Thank you.

Senator LIEBERMAN. Thank you, very much, Mr. Lloyd for that perspective from California.

I want to welcome our colleague, Senator Harry Reid.

Senator Reid has been very active in pursuing the possibilities of hydrogen-powered fuel cells.

Do you have an opening statement at this time, Senator?

Senator REID. I do not, Mr. Chairman.

Senator LIEBERMAN. It's nice to have you here.

Let's move on now to Albert Sobey, a consultant on American auto manufacturing, from Bloomfield Hills, Michigan.

Welcome.

STATEMENT OF ALBERT SOBEY, CONSULTANT

Mr. SOBEY. Thank you, Senator Lieberman, Senator Kempthorne and Senator Reid.

I am an independent consultant working largely with the State of California, Department of Energy at this point in time.

I should say my background includes research on everything from aircraft engines, rockets, innovative cars, to new transportation systems. In fact, one of the things I did some 30 years ago was form a company for innovative transportation systems which now United Technology owns and operates. I retired from General Motors in 1987, so that has been the bulk of my experience.

I understand that this hearing was to address really four basic questions and I'd like to hit each of these briefly. What can be done to create a quick, clean car? Why hasn't more been done? How can the process be accelerated? What are the implications for international trade?

Let me start with the opportunities for reducing pollution from cars. It has been alluded to but the automobile is only one element in our personal transportation system. There are environmental implications at every stage—production of raw materials, production of fuels, design, manufacturing, as well as their operation and

disposal. I will concentrate on propulsion vehicle concepts and operation.

There is clearly still some opportunity for reducing not just emissions from the piston engines, but it is an area where invention is still possible and an area where innovation has not been totally exhausted. Experience, however, has said that as you move toward lower standards, the costs have tended to go up exponentially.

If you wanted to use new fuels, hydrogen happens to be a very popular fuel at this point. Engines on hydrogen would generate no noxious emissions, nitrogen oxides, and no carbon dioxide. It may be an ideal engine fuel but it is not an ideal fuel to transport or store in a car. Maybe other methods of transporting hydrogen may be developed but the obvious one is use of methanol which can be disassociated into hydrogen on the vehicle.

There are several other new propulsion systems besides the piston engine or fuel cells (which I will get back to) which are worthy of mention, gas turbines and sterling engines and I will say a word about battery electric.

Automotive gas turbines have had a disadvantage because with the earlier turbine temperatures limits their propulsion and energy efficiency falls off rapidly with reducing power. However, the recent development of high temperature turbines under DOE contracts may permit them to be competitive in fuel consumption and meet California's low emission standards and still yet to be confirmed, to be price competitive.

The sterling engine is an external combustion engine. It can have the lowest emissions of any thermal engine, but the first sterling engines were costly and had mechanical problems. There are some recent design developments which appear to have solved these problems. In fact, Detroit Diesel is now planning to offer a small sterling engine for sale at roughly the same price as a comparable diesel engine.

Battery propulsion is a nice way to get a clean car, but as you all know, it has cost and performance limitations which I will get back to the industry feels that except for some niches—people are unlikely to purchase many battery cars.

The fuel cell has already been mentioned. I believe that it will be ultimately the propulsion system of choice for all ground vehicles. As has been said, it emits essentially no noxious emissions and only carbon dioxide. You can use a hydrocarbon fuel and still generate less than half of carbon dioxide.

Senator REID. What kind of fuel cell?

Mr. SOBEY. There are five different kinds of fuel cells being discussed, each of which has advocates, each of which could in fact become the fuel cell of choice. At this point, I cannot tell you which one will be the winner. I have a personal idea but I really don't know which one will be the winner.

One problem with the fuel cells is that the fact that they are technically feasible can be misleading. It's going to take years and billions of dollars, as Alan mentioned, to reduce their cost to a level acceptable for the private automobile.

There are some other options as far as the automobile is concerned besides propulsion. You can reduce weight, reduce drag, rolling resistance, change the acceleration capabilities. Of these,

only the weight reduction leaves much promise at this point. The automobile manufacturers and suppliers are developing lightweight economic materials. I'm confident that they will eventually solve the manufacturing cost problems but it will take some time.

As we require longer maintenance on the environmental standards for the automobiles, if you require 100,000 miles, the technology has to be good for much more than 100,000 miles we're beginning to see in the industry more use of corrosion-resistant materials, less subject to damages, new propulsion systems like fuel cells. These may extend the life of the car almost indefinitely. In fact, you can visualize the day which people upgrade their existing cars rather than purchase new ones. They may change the appearance and the accommodations of their cars to match their lifestyle changes. As a result, we may not have to dispose of as many car carcasses as we did in the past.

There are also some opportunities in unique kinds of cars, nontraditional cars. For example, studies are in process in California in what the State calls narrow lane cars. In over 80 percent of commuting trips, the driver is the only occupant and a good, single passenger car might be acceptable for commuting. Such cars have been proposed with fuel mileage on the order of 120 to 150 miles per gallon.

In most cities, there's another niche. Over half the trips take less than 10 minutes. Most shopping trips take less than five. These trips could be served by a light car powered by conventional batteries. We don't necessarily need a battery breakthrough to meet that market.

Southern California Edison has estimated that the use of light battery cars for all of the trips in Alan's area, 8 miles or less, could cut emissions roughly in half. These kind of cars would permit people to continue their lifestyles and still be environmentally responsible.

Other possible improvements are in the way traffic controls are handled, reduction of delays at traffic signals. Some studies say they could save up to 20 percent of the emissions.

I believe that these technologies will be best used first in other vehicles that have less stringent economic requirements than the automobile. In buses, they can reduce complaints about emissions, noise and smells. Actually, the first commercial application may be locomotives where it looks like the life cycle costs will be less than for diesels and considerably less than electrification.

It's these kinds of applications that will provide the experience to develop what I would call a second generation of fuel cells. Those that are economically competitive for the automobile.

We were also asked why hasn't more been done? There are several reasons why the automobile industry has not made as big commitments as some would like to this field. These include the pressure to meet the near term requirements and certainly the benefits and their inability to foresee a profit.

While innovation can be a threat in the culture to some middle management, it no longer, I think can be said, is a threat to top management. They will do what it takes to stay in business, to meet foreign competition, to comply with the regulations, and to provide a better product for the customers.

The research and development costs for new technologies are high. If industry is called on to amortize these costs directly, just the interest payments alone could result in the engines being uneconomic, even if the manufacturing costs are competitive with existing engines.

Money is not the only constraint. The number of engineers who can contribute to advanced propulsion is limited. The use of engineers and scientists, as mentioned earlier, from aerospace is an option but having gone through the transition, I can tell you it is not an easy one to make. It's going to be a challenge for the academic community to bring the people up to the ability to work in this industry.

There a number of regulatory problems which the industry is concerned about. There are regulations on the books that do inhibit the use of advance propulsion, some designed not for automobiles but for houses and other uses, transportation of fuels that have to be addressed.

Even when regulations should be changed, for example, to permit unconventional or advanced vehicles, the repermitting, or the time required to develop a new regulation may be as long as the time to design the product.

One of the major priorities of the industry is safety. The product liability legislation has made most companies reluctant to introduce new concepts. In fact, they need a safety record that the insurance companies can use first and as it stands right now, this may have to be done somewhere else besides the United States.

Senator LIEBERMAN. Because of product liability laws here.

Mr. SOBEY. So I really doubt that fuel cells or other advanced propulsion systems will be commercialized in the United States unless there are ways to write off the R&D costs and to avoid the other barriers which are inhibiting the industry's interests.

You asked also how we can accelerate the commercialization. The industry needs the type of support I just described. It has been suggested that consortia teams made up of government laboratories and private companies working toward common goals could accelerate this process. I agree. If we structure it such that all participants benefit either from an increased budget if you're a Federal laboratory, or private industry profits, and if the program is designed to continue uninterrupted through commercialization as long as major milestones are met. To avoid the delays of rebidding or the delays that typically get involved in these kinds of programs.

The Government's share should be proportional to its risk, highest perhaps 80 percent at the beginning and negligible as it approaches commercialization. This would be similar to the way our foreign competitors approach similar problems.

I do have some reservations on joint research and development between industries. I don't have any concern over basic research, although this is the area where government is most helpful. My concern goes back to the reasons for the complacent attitude the industry took toward forward competition. All U.S. manufacturers had similar labor costs, similar material costs, similar suppliers, and what they thought was buyer loyalty. These companies had few incentives to take risks. They did have different technical

staffs and some detailed differences in how they approached the problem and enough inside work that they developed a not invent it here attitude, which has changed dramatically, but if they do draw from the same technological base, we may just inhibit innovation in technology.

What we really need is parallel paths. My analogy is the aircraft flyoffs in the military. I don't think we know enough to know the answer. Even when we know the answer,—to what appears to be best—today there will be invention and new ideas developed by the people who are working on the product.

The last question was the implication to international trade. Let me say if we are going to penetrate that market with anything like fuel cells or new technologies, we have to accelerate the process. In fact, we may already be too late. Our competitors are moving fast. In fact, the question may actually be what countries do we buy our products from, not how do we sell products to them.

In conclusion, I don't see clean car initiative winding up for the futuristic family sedan on a pedestal or even with a set of mandates. What I see is a process, a process for determining how to reduce emissions as new technologies are developed. We haven't ended our line of innovation. There are things out there that we don't know of yet that could very well be important in this whole process.

Government needs to share the risks; things need to be done on a time schedule which doesn't require the industry to choose what I would call second best solutions, but rather, to work on ultimate solutions, and not to hurry products into the market before they are ready and get them a bad name. Sometimes you lose support for technology for the damndest reasons. I've lost programs because it rained the day I tried to demonstrate something.

There is no question that implementing this technology is going to cost more, take longer than we would like, but I think it's going to take less time than most engineers think it will, and I am confident that with time, the cost to the consumer will be less than most engineers think it is. It's still going to take a long time.

Senator LIEBERMAN. Thank you, very much, Mr. Sobey for that interesting testimony.

Next we will go to Jack Smith, Manager, Natural Gas Vehicle Marketing, Southern California Gas Company. Mr. Smith is going to testify about the use of natural gas in fleet vehicles and the potential for their use in passenger vehicles.

Welcome.

STATEMENT OF JACK SMITH, MANAGER, NATURAL GAS VEHICLE MARKETING, SOUTHERN CALIFORNIA GAS COMPANY

Mr. SMITH. Thank you very much, Senator.

As you indicated, my name is Jack Smith. I'm the Natural Gas Vehicle Marketing Manager for Southern California Gas Company.

I'm here today representing not only Southern California Gas Company but also the Natural Gas Vehicle Coalition, a national coalition made up of over 200 members, including automakers, equipment manufacturers as well as leading local distribution companies

in this country. I'm here today to share something not so much in the future but something that's available today.

Southern California Gas Company is the largest gas utility in the Nation. We are also located in the poorest air quality region in the Nation. Our general service area, known as the South Coast Air Basin, is where over 70 percent of air quality problems are directly attributable to the over 10 million vehicles we have currently operated in the LA Basin.

Southern California Gas Company is aggressively pursuing the development of a natural gas vehicle market. In fact, they are investing about $15 million a year toward that end. We're doing this for three reasons: first, because we have a stake in and a commitment to improving the quality of life and enhancing the economic vitality of the communities that we serve. Like other utilities, our investment as a company primarily take the form of pipe in the ground. If the business climate turns bad for us, we can't take our 40,000 miles of pipe out of the ground and move it to Georgia or the Carolinas. Given this, our financial well-being as a company is really largely dependent upon the economic health of our customers.

The second reason we're doing this is simply because it makes good business sense to do so. We're projecting a much higher level of financial returns from the development of a natural gas vehicle market than we are from our more traditional investments in pipeline.

Third, because as we see it, natural gas is the only viable transportation fuel, it has the ability to improve the breathability of our air and at the same time, reduce our reliance on foreign energy, and at the same time, even has the potential to drive down the cost of driving.

What I'm going to share with you this morning briefly is a little bit about our program to develop the natural gas vehicle market, and share with you some of the emission results we've received on natural gas vehicles that are currently being manufactured and currently operating in this country.

Southern California Gas Company's program really has two primary objectives: first, to initiate development of the fuel infrastructure which is so badly needed, and second, to get vehicles on the road that truly meet our customers' needs.

In regards to developing the fuel infrastructure, last year we opened up 24 new fueling stations and by the end of this year, we will have 51 new natural gas fueling stations opened in the Los Angeles Basin.

Senator LIEBERMAN. Are they just natural gas fueling stations or are they combined with more traditional gas stations?

Mr. SMITH. A combination. Some of these stations are installed with companies such as Federal Express, UPS, which are private, and other stations are being installed with Shell, Unocal and Chevron. In fact, beginning this year, our plan is to open one new fueling station every week and a half for the next four years.

Our program to get vehicles on the road which we think will clearly demonstrate the real viability of using natural gas as a transportation fuel really consists of three components. First, we're offering incentives, vehicle incentives up to about 50 percent of the

incremental cost of a natural gas vehicle or 50 percent of the cost to convert an existing gasoline vehicle to natural gas.

Probably more importantly, we're offering a fuel price for compressed natural gas that is currently 26 cents below the wholesale price of unleaded gasoline.

Senator LIEBERMAN. What is that figure again?

Mr. SMITH. Twenty-six cents below the wholesale price of unleaded fuel per the Lundberg survey.

Senator LIEBERMAN. The wholesale price?

Mr. SMITH. The wholesale price.

Senator LIEBERMAN. Not the retail price?

Mr. SMITH. That's right. In fact, that is our approved Public Utilities Commission rate-setting methodology for our compressed natural gas service. It's an index rate, like I said, geared toward the wholesale price of unleaded fuel.

Senator LIEBERMAN. Just go back a minute, if you will, while you're on cost. You mentioned, if I heard it correctly, that as an incentive, the company is paying 50 percent of the price of conversion of vehicles to natural gas?

Mr. SMITH. Yes, we currently are, sir.

Senator LIEBERMAN. What is the estimated price of converting a vehicle?

Mr. SMITH. It depends on the vehicle size. The biggest driver of the cost of a natural gas vehicle has to do with the cost of the onboard fuel storage cylinders, generally the larger the vehicles, the more cylinders required. For example, GMC is currently offering the CK pickup truck at about $4200; Chrysler is offering their full-size van at about $3800 incremental price; and the cost to convert a vehicle, a light duty truck or van such as this, would right around $3,500.

Senator LIEBERMAN. So you would pay half the cost. Do I understand correctly that we're not just talking about fleet but also individually owned passenger vehicles or are you talking just about fleets now?

Mr. SMITH. Our initial targets are primarily the fleet vehicles. This is where the regulatory impetus has been to initiate change and it's also where we need to go to begin development of the fueling infrastructure.

I think what is more important than incremental vechile price though, Senator, is that we project that ability to maintain a significant fuel price differential over gasoline well beyond the end of the decade.

The third major component of our effort to get vehicles on the road has to do with our joint development programs with the major auto manufacturers and engine manufacturers across the country. These programs have resulted in a broad line of vehicles that are currently available directly from the original equipment manufacturer and, in fact, represention expanding product line.

GM, for example, this year expanded its offering of pickup trucks to include the half as well as the three-quarter ton truck. Chrysler will begin offering the extended version of its full-sized van this year. This is the vehicle that is probably the most popular vehicle for van pools. Ford announced in February their intention to begin producing the natural gas version of their Crown Victoria in 1996.

And Late in February, Chrysler announced plans to produce a natural gas version of its popular minivan. This will result, two passenger non fleet types of vehicles.

I'd like to share with you now some emission results. First from some heavy duty vehicles, these are the certification figures from Commins transit bus engine. This engine is currently being used to power several transit buses across the country. In fact, 40 are going into Sacramento Municipal Transit District. The Los Angeles Airport just ordered 12 of these buses with this engine to be fueled with liquefied natural gas as opposed to compressed natural gas.

Senator REID. What does that chart show?

Mr. SMITH. This is a comparison of the certification numbers achieved by Cummins when they certified the engine compared with the California Air Resources Board's standards. On the back in green is the California Resources Board standards and the bars in yellow are as a percent of where that engine certified to.

Senator REID. You're below this California Air standard?

Mr. SMITH. Yes. This engine certified to about 50 percent of the allowable emissions of nonmethane organic gases and about 30 percent of the allowable NO_x emissions.

Another engine that is very popular in shuttle buses and school buses is another diesel-derived engine. As a matter of fact, over 50 percent of the dash shuttle buses currently being operated by the City of Los Angeles are currently using this engine. Shown here is, the same type of comparison between the CARB 1993 standards, the 1994 standards and the emission achieved by the Hercules engine. As you can see, this engine did very well compaired with all the standards, especially important is that emissions of nitrogen oxides and carbon monoxide was extremely low and only a fraction of the total allowable.

Let's move to a couple of light duty vehicles and where some of the Chrysler products have tested at. Shown here are the emission results obtained during certification of the 1992 Dodge Ram Van, compared with the ever declining Low Emission Vehicle regulations in California.

You can see starting on the lefthand side where we are with the 1993 standard, the 1995 standard, the 1998 low emission vehicle standard, and then what is called an ultra low vehicle emission standard.

Senator REID. What is the green and orange?

Mr. SMITH. I'm sorry?

Senator LIEBERMAN. What is the green and orange?

Mr. SMITH. Those are the different types of emissions. NO_x is shown in orange; carbon monoxide emissions are shown in green; nonmethane organic gases are shown in yellow.

As you can see, this Chrysler van, when it was certified, was well, well below the ultra emission vehicle standards. In fact, on NO_x, which is the primary criteria pollutant in the Los Angeles Basin for forming smog, an ultra low emission vehicle standard is .6. These vans came in at .02. In fact, in 1993, this Chrysler van was recertified as the first low emission vehicle ever produced. That vehicle is available today.

As I mentioned earlier, last month Chrysler announced its intentions to produce a natural gas version of its popular minivan. At

that time, it also released the results of its emission testing and compared those results, first, with the California ultra low emission vehicle standards and then with the emissions that they get from their electric T-van including powerplant emissions.

In the box is where the minivan emission numbers are. The top two lines are the ultra low emission vehicle standards. As you can see, in terms of nonmethane organic gases and CO, the Chrysler minivan achieved 50 percent of the allowable emissions of an ultra low emission vehicle. In fact, on NO_x, the criteria pollutant for smog formation, this Chrysler minivan was 20 times cleaner than the ultra low emission vehicle standards.

Compared to electric vehicles including powerplant emissions for the source generation mix in the Los Angeles Basin, this vehicle achieved NO_x levels four times cleaner than electric vehicles. On a national basis, if you include that kind of national mix of powerplant emissions, this vehicle is 60 times cleaner on NO_x than the electric vehicle. Chrysler intends to begin producing this vehicle in January at a cost of about $3,000 incremental price.

In summary, I'd like to point out that, the rather spectacular emission results that have been achieved thus far with natural gas vehicles has not been as a result of millions of dollars of research and years of development work, but in fact, with only a minimal amount of time and money. That Chrysler minivan was produced after about $1.5 million worth of engineering in about a little less than a year's worth of time. That's the kind of potential, I think, that natural gas has and that's why I think natural gas should clearly be the environmental choice for transportation.

Thank you.

Senator LIEBERMAN. Thank you.

Our final witness is Gary Davis. With no personal denigration involved, I was about to say that you're sort of like the tail on the dog of this hearing, not just that you're at the end, but we wanted Gary, who is the Director of the Center for Clean Products and Clean Technologies at the University of Tennessee, to come and talk about an issue that is not directly related to clean car emissions, but to what we take to be an important part of the marketability of vehicles worldwide and in this country. That is the ability to recycle components of the automobile.

I know you have some experience both with the German situation and you've also worked closely with the Saturn operation in Tennessee, which has initiated an aggressive recycling program.

We welcome you and we look forward to your testimony.

STATEMENT OF GARY A. DAVIS, DIRECTOR, CENTER FOR CLEAN PRODUCTS AND CLEAN TECHNOLOGIES, UNIVERSITY OF TENNESSEE

Mr. DAVIS. Thank you, Mr. Chairman and distinguished members of the subcommittee.

The Center for Clean Products and Clean Technologies at the University of Tennessee is an interdisciplinary research center that focuses on encouraging the use of products and processes that reduce pollution throughout their life cycles. We are currently engaged in a project with the Saturn Corporation, a division of Gen-

eral Motors, that is part of what is called the UT-Saturn Partnership. As you probably know, the State of Tennessee is a major automobile manufacturer, having the Saturn plant as well as a Nissan plant, very large facilities.

By way of disclaimer, I'm not speaking on behalf of the Saturn Corporation today and am not expressing any opinions for that corporation.

I will address three topics. First is automobile recycling in Western Europe; second, the use of what is called life cycle assessment as a tool to redesign automobiles to make them less polluting; and third, the Saturday Corporation's recycling initiative and some of the other design for the environment initiatives within the Saturn Corporation. I have made available more detailed materials for the subcommittee's review and will restrict my remarks to the time allotted, even shorter.

First of all, Saturn sponsored a research trip by myself and one of my engineers in October of last year to Western Europe to look at European recycling initiatives. We visited Germany, Sweden, France, the Netherlands, Switzerland and obtained materials from other countries as well during that trip. We've kept in touch with the researchers that we met with in Europe.

There are basically three factors that are driving the recycling of automobiles in Europe. First of all is a concern regarding the land disposal of shredder residue, particularly the shredder residue that comes from plastics that are incorporated more and more in automobiles. This shredder residue can create problems when disposed of in landfills because it contains heavy metals and other materials that can leach into the groundwater and create groundwater contamination.

The second major factor driving automobile recycling initiatives is a concern over the conservation of materials.

Third, companies are trying to create a greener image in order to sell more cars and that is another major factor driving recycling programs in Europe.

Of course regulations are also driving European automobile manufacturers to look at recycling and there are basically three types of regulations that we saw in Europe that are really coming on. First is the German approach, which I call takeback regulation. Under the German waste law, the Ministry of the Environment has developed regulations that will require automobile manufacturers to take back cars after their useful life for free and to manage those automobile hulks in an environmentally responsible way.

The German regulations also require manufacturers to extend the useful life of the automobile and the regulations set goals for recycling the parts of the automobile. Those goals are 100 percent for steel, 90 percent for nonferrous metals by the year 2000, and 50 percent for plastics by the year 2000.

There is also a chance that this German approach will be implemented Europewide through the European Community regulations. It's anybody's guess yet the final shape of the European Community regulations on automobile recycling.

Another approach that is being used, particularly in the Scandinavian countries, is similar to the bottle bill type legislation that we've seen in the United States where purchasers of automobiles

pay an additional amount of money when they purchase a new car and at the end of the useful life of the automobile when they deliver the automobile to a registered auto dismantler, they receive a refund from that payment. It's like a deposit.

Senator LIEBERMAN. Is that being done now?

Mr. DAVIS. It's being done and has been done for several years in Sweden and other Scandinavian countries.

The third regulatory approach driving the concern over recycling in Europe is bans on land disposal of automobile shredder wastes which again stems from the concerns over groundwater contamination. Switzerland and France have both set bans on the land disposal of this waste, pushing toward more incineration of shredder residue. The EC regulations being developed for automobile recycling are driving by the designation of shredder wastes as a priority waste within the European Community. So there may be an approach that combines both the land disposal ban with a recycling initiative that will ultimately come out of the European Community.

This means a lot to American car manufacturers because in order to sell cars in that European market that we've heard about today, American car manufacturers will have to meet those standards, whatever they will ultimately be. In the German market, American car manufacturers have already started looking for local partners who can form the nucleus of a recycling infrastructure for American manufacturers as well in Germany.

There are three components to a recycling program for automobiles. One is the disassembly of the automobile; two is the infrastructure for collection and recycling; and three is the actual recycling of the parts. I could answer any questions about that, but those are covered in more detail in the materials. Suffice it to say that there are numerous materials used in the standard automobile. One component, like a dashboard, for instance, may contain as many as ten different materials. So you can see the problems in both dismantling an automobile and in recycling those parts, particularly since many of them are plastic parts.

BMW had probably the earliest recycling program in Europe and began planning the program in 1984. It looks at what is called a cascade model for recycling meaning that you start with the high value parts that can be reconditioned and resold, dismantle those, take them out, recondition them. You can make a lot more profit off those.

Second is materials recycling where you recover the material itself. Third is chemical recycling where you can convert a plastic material into a chemical that can be reused. Last is energy recovery and if that can't be done, disposal of the remaining residue.

BMW has a pilot disassembly plant in Landschute, Germany which disassembles five cars a day now to develop disassembly manuals to be ultimately used to help meet this German regulation.

Briefly, I want to touch on life cycle assessment which is a tool for looking at the environmental impacts of a product system throughout the whole life cycle of the system. Some call it cradle to grave, I call it lust to dust because cradle to grave is not early enough or late enough.

Life cycle assessment includes an inventory of inputs and outputs into the manufacturing process and includes an assessment of the impacts of those effluents or emissions. It also includes an improvement analysis for a manufacturer to improve the environmental performance of a product by looking at this tool.

It can apply to the design of a product or components of a product. It can also apply to an infrastructure or a system like a recycling system because there is a lot of different ways to do recycling and set up a recycling program.

Europeans are looking at using life cycle assessment as a way to redesign the automobile to make it less polluting throughout its whole life cycle. The University of Stuttgart that we visited is working on behalf of 25 to 30 companies in Germany, including the manufacturers themselves as well as the materials suppliers. A French consulting firm is working for French automobile manufacturers to do the same thing. Volvo has its own system that it has developed for looking at the life cycle of products.

I will say that it's clear to me, as it is to other researchers that are looking at the life cycle of the automobile, that the most significant environmental impacts are caused in the use of the automobile. That's extremely clear but there are other impacts that are quite significant when you look at the manufacturing processes, when you look at the disposal of the automobile that may have significant local effects, particularly with the use of toxic chemicals in manufacturing and in the disposal of these materials at the end of the life of the automobile.

Just a couple of points about Saturn's initiatives in this area. Saturn has a goal of approaching 100 percent recycling by the year 2000 and also has a goal of incorporating life cycle assessment as a tool in redesigning the automobile, both for ease in recycling as well as for longer term environmental impact reductions. Saturn has found that recycled materials used in the automobile can save money, anywhere from 30 to 60 percent on some recycled materials.

In conclusion, a substantial increase in recycling of automobiles is possible with a reduction in the impacts of disposal of shredder residue. It will take cooperation between automobile manufacturers and their materials suppliers, as well as cooperation with government, and that's where this clean car initiative comes in. It may ultimately be necessary to achieve these levels of recycling for American car manufacturers to sell cars in Europe. That may be the bottom line here.

Life cycle assessment can be used as a tool for redesigning the automobile, but it's clear the biggest environmental impacts come from the use of the automobile and not necessarily from the manufacturing or disposal.

The University of Tennessee, Center for Clean Products and Clean Technologies, will be happy and interested in supporting the clean car initiative in any way we can.

Thank you.

Senator LIEBERMAN. Thanks, Mr. Davis.

I take it that Saturn is ahead of the rest of the domestically produced automobile makers?

Mr. DAVIS. I can't say that for certain.

Senator LIEBERMAN. It's just that you've worked with them and you know what their goals are.

Mr. DAVIS. Yes, sir. One thing Saturn has done ahead of probably anybody in the world is develop a method of recycling painted, plastic automobile body parts and they are very proud of that accomplishment.

Senator LIEBERMAN. Senator Reid?

Senator REID. Mr. Chairman, I have to leave. I do want to say this to you and say it publicly. I think this is a great hearing. As you know, in my subcommittee we've held hearings on hydrogen fuel development; there is going to be a demonstration I'm sponsoring tomorrow on solar energy. I think that we should, and we will talk about this in more detail, combine our efforts and have the two subcommittees work together on this. It's unnecessary you hold a hearing or I hold a hearing. We can have the two subcommittees jointly do this. I think we can make some great progress.

I do want to say one thing—I can't resist this—before I leave, and that's in regard to the statement that I find in Mr. Sobey's testimony. I only point this out just because it's one of the things that really upsets me.

> The automobile industry places safety at the top of its priority list but the growth of product liability litigation has made companies reluctant to introduce radically new concepts. New operating technologies will seldom be introduced until there is a safety record which insurance companies can use.

I won't read it all but I think this is sad commentary on our automobile manufacturers if they are afraid to do something new because they are worried about possible suits. That is too bad and I think it is wrong and I think it's just like medical malpractice being the reason for driving up medical costs. It's a red herring. It's not valid, it's not true, and I think if this is why we've had so much trouble getting new technology in the automobile industry, it speaks very poorly of our whole system.

Mr. SOBEY. May I respond to that, sir?

Senator LIEBERMAN. Go ahead, Mr. Sobey.

Mr. SOBEY. I agree with your comment in the broader sense. On the other hand, it has been true.

Senator REID. You're stating a fact and I'm not criticizing you, I'm criticizing the concept.

Mr. SOBEY. The concept is that if you are building a new product and you look at it as a lawyer within a corporation, any corporation, and say the risk of something going wrong with that production.

Senator REID. I think we should kill all the lawyers, either that or——

Senator LIEBERMAN. Particularly since you and I are not practicing anymore.

Senator REID. That's right. Especially.

[Laughter.]

Senator LIEBERMAN. Right.

Senator REID. Or perhaps we should either eliminate this as a reality or give these companies some protection.

Mr. SOBEY. Let me make a comment on that. One product which I have been fighting for, as some people in this audience know, for more than 15 years has been held up by that particular problem.

The State of California has agreed to take the liability risk during the demonstration.

Senator REID. That's great.

One last thing. In the hearings that I have held and the work I have done for several years now, the South Coast Air Quality District has led the country in almost everything dealing with air pollution. I think they are to be commended. I think last year they spent $9 billion or some figure like that trying to work out their problems. So every time we have a hearing that deals with air quality, South Coast has to be involved in it because they are so far ahead of everybody else.

Thank you for allowing me the time.

Senator LIEBERMAN. Not at all, Senator Reid. We got into this in this subcommittee because of the oversight of the Clean Air Act implementation. I'd be really delighted to work with your subcommittee and hopefully we can focus some attention on what's happening, what the possibilities are, and whether there is an additional constructive role for the Government to play in making sure that we develop these clean air cars which will, I think, protect the health of the automobile industry as well as protecting our own health.

Senator REID. It's amazing and I didn't realize it was so pronounced, but from the 62 standards, it took one 1962 car to emit as much pollution now as 100 cars, modern day cars.

Senator LIEBERMAN. We've come a long way.

Senator REID. But the problem is we have so many more cars.

Thank you, Mr. Chairman.

Senator LIEBERMAN. Thank you.

I'm going to begin the questioning.

I want to pick up on the last statement and ask you, Michael, at the outset, your charts were very impressive in many regards and one was this extraordinary growth in automobile production and use around the world. We heard testimony today about the rising level of standards that the European Community is putting into effect, but as other developing nations try to satisfy what seems like an inevitable quest for automobile usage, is it clear they are also going to demand cleaner cars? In other words, wouldn't they be worried that those cars might cost more and therefore, really want to get the cars and worry later about the quality of the air?

Mr. WALSH. That's a very good question, Senator. Somewhat to my surprise, it's remarkable to me how many countries that are quite poor are beginning to demand clean vehicles. If one spends any time in Thailand, especially in Bangkok, the host of problems that plague the general public in that area are enormous and yet they have identified air pollution as a serious impediment to their future development, not only in terms of its impact on its own people, but also in terms of its attractiveness as a place for industry, tourists and so forth. So they see cleaning up the environment as an integral part of their economic development. I just use them as one example. I think there are many examples like that. That is becoming more the norm rather than the exception. One could say the same, for example, about Eastern Europe as it has developed.

Senator LIEBERMAN. Let me ask you, in your general capacity as a consultant, to step back and take an overview but look forward.

We're creating all these incentives and indeed, requirements for cleaner vehicles. There are a lot of different ways that we've heard testified to this morning about ways in which people are beginning to try to do that—electric cars, natural gas, fuel cells, and so on.

How is this all going to develop in the ideal world? How should it develop? In other words, are we going to go through a period of time where there will be a kind of market competition among these various alternatives? Is there ultimately going to be, as a few people have either argued or predicted, an alternative of choice? Should we somehow all be getting together and trying to decide what that is now and pool our resources to develop it?

I asked you two things. One is to project what is likely to happen and then whether government, I suppose, should try to intervene to determine what happens in a more aggressive way?

Mr. WALSH. To deal with the second part of your question first, I think the role of government, the most significant and beneficial role of government, is to create the market and a climate for the competition for that market to take place.

Senator LIEBERMAN. By setting standards?

Mr. WALSH. By setting standards, that's correct, or other types of incentives in addition to standards.

Each time I tried in the past to step back and predict a technological winner, I become very humble because the ingenuity of the vehicle manufacturers to come up with ways to comply is very substantial. In September of 1990, when California adopted their emissions standards, they predicted that virtually all of the vehicles to comply with the low emission vehicle requirements and ultra low emission vehicle requirements would require an electrically heated catalyst that would have to be turned on before the vehicle got turned on. Today, we feel that only a small proportion, if any, vehicles, will require a heated catalyst and virtually none of them preheating. The technology advances just with conventional technology have been dramatic.

I think, to go to your first question, creating the competition is the best way to get winners and if I would disagree a little perhaps with some of the other speakers, I don't think there will be a winner. I think if we create the right climate, there will be several technologies. In some vehicles, it will be a natural gas vehicle that will be the right vehicle; for others, it may be fuel cells or electric vehicles; or maybe the Sterling engine will come back; and I think we will be surprised at how many vehicles using conventional technology will get very, very clean. So I don't think there is a single winner that will emerge ultimately.

Senator LIEBERMAN. Let me ask the panel generally and leave it to you to volunteer in response. What obstacles would you say are the most serious now that exist to the development of some of these clean technologies and what are the manufacturers doing to overcome some of those obstacles? Mr. Sobey, do you have a view on that?

Mr. SOBEY. Yes. I think there are a couple of serious obstacles. One of them is just plain money, the ability to forecast a profit, put it in context.

Senator LIEBERMAN. I'm sorry, say that again?

Mr. SOBEY. The ability to forecast a profit. As it stands now, if I may use a number which may be a little overstated The University of Michigan has estimated that the industry will require something like $250 billion in investment just to remain competitive, not new technology.

Senator LIEBERMAN. $250 billion?

Mr. SOBEY. $250 billion.

Actualy, $225 billion. At the same time, they expect the foreign auto companies to invest about $375 billion. There is no way the U.S. companies can match that. They don't have that kind of money. That's a little something over three times the rate of spending in the past. So there is a major problem. How do you get the resources clear, free and the question that faces top management, survive.

Senator LIEBERMAN. Is that over a period?

Mr. SOBEY. That's 5 years.

Senator LIEBERMAN. That's a five-year period. So truly the availability of capital, as you see, is the most significant deterrent to the development of the cleaner car?

Mr. SOBEY. The second major one is one I mentioned which is the resources in terms of the technical people who can do the work. There is only a limited number of people who have been working on these advanced technologies.

Senator LIEBERMAN. Michael, did you want to add to that?

Mr. WALSH. Yes, Senator. I think another factor is some question on occasion in terms of the commitment of government to really carrying forth with the objectives it states. I would cite the example of fuel economy. During the 1970's, we set out, on the government level, a very stringent series of requirements and then sort of after significant investment by industry to comply with those requirements, we seemed to waiver quite a bit during the 1980's in our continuing commitment to fuel efficiency.

I think that fosters a skepticism on the part of some in industry that government is really serious about some of these goals.

Senator LIEBERMAN. Of course that's something we hear all the time from business folks. I may disagree with what you're going to do, but whatever you do, unless it's really horrendous, stick with it so there is some predictability in the world we live in.

My time is up. Senator Kempthorne?

Senator KEMPTHORNE. Mr. Chairman, thank you.

Mr. Smith, with regard to your presentation on natural gas. I know that there are a number of mid-sized communities in America that are trying to move to these alternative fuels, particularly in mass transit, the buses that would use the compressed natural gas. I say mid-sized cities because they don't have such a large fleet, the 40 buses that I think you referenced for Los Angeles. It may be three or four at a time that they can acquire to put into their fleet, but one of the problems is a central distribution point for that compressed natural gas. The cost almost becomes prohibitive to putting in the distribution point and therefore, they have to question if they should begin the conversion.

Do you know if the task force will deal with this question of infrastructure and also the cost?

Mr. SMITH. Certainly infrastructure and cost are key components. I should also add that technology is evolving too. Today, we have very small compressors now that are very cost effective, actually residential home refueling units is what they are called. These have been certified and we're installing 100 of these units this year out in Los Angeles.

Beyond that, you kind of have to jump up to that fairly large station but as said, there is a lot of technology developing to bridge the gap and get to where three to four buses would, in fact, become economical.

Another possible choice is the use of liquefied natural gas as opposed to compressed natural gas as the economics can look better for the total package, combining vehicle costs and fueling stations.

Senator KEMPTHORNE. Because we don't want to inhibit the systems going toward these alternative fuels but yet there are so many component parts that make it prohibitive.

Many of the rural States, agricultural States, have been turning to ethanol as an alternative fuel. This may be for anyone but in anticipation of this hearing, reading up on some of these alternative fuels, there was one quote that said, "Ethanol would offer smaller air quality benefits than methanol and may be detrimental to air quality when used as a blending agent with gasoline."

Considering that ethanol production costs have dropped and that the costs for ethanol conversion are negligible compared to some alternative fuels, is this assessment, this quote warranted or should we be continuing to look at ethanol? Mr. Lloyd?

Mr. LLOYD. We've looked most heavily at methanol but we're also looking at ethanol. We currently have a vehicle which is being converted to ethanol. We don't have enough emissions data to really do a first rate job.

My feeling on ethanol has in fact changed slightly over the last couple of years to being more positive toward ethanol. The air quality benefits, we feel are smaller than methanol but clearly better than existing gasoline. The cost side comes back to that in terms of the subsidies with ethanol and I think that's the major issue that we have. In terms of an air quality impact, we feel it's worth looking at and in fact, where it's a viable fuel, we're pursuing that from an air quality viewpoint. We would like to do some more characterization.

Senator KEMPTHORNE. So ethanol is a viable alternative that should be pursued?

Mr. LLOYD. The cost I'm talking about now take the costs out of that. I think if you take the cost out because of the subsidies, then the cost may be prohibitive without the subsidies, but from an environmental viewpoint, I think it's still worth looking at. In fact, we had a program with Federal Express, the so-called Clean Fleet Program, where we are in fact looking at five different fuels in a Federal Express Fleet Program. That will be looking at electric, natural gas, propane, methanol, reformulated gasoline and base gasoline.

That program was set up at the instigation of the ethanol industry to in fact try to get some comparative data but in fact, they dropped out of it because they basically did not want to abide by a certain set of guide rules that the rest of the fuel vendors did.

While I've got the floor, I'd like to make one correction here to Senator Reid's comments. I appreciate his positive comments on the South Coast Air Quality Management District, but our budget is basically just over $110 million.

Senator LIEBERMAN. You wouldn't reject the increment he suggested though?

Mr. LLOYD. With the heat we're under, we will take it.

[Laughter.]

Senator KEMPTHORNE. Let me ask also to what extent has the technology that we've gained from space exploration contributed toward answering some of the questions and some of the technological needs that we have in our transportation needs and in assuring that we continually seek environmentally sound solutions? Has space technology been helpful in what we're trying to accomplish here?

Mr. SOBEY. If I may respond to that, in the case of the fuel cell technology, in the case of gas turbines, both. The fuel cell technology, as it stands now, is the aerospace industry. There's one substantial difference between how aerospace approaches it and how the industry approaches it, which is costwise.

Having looked at the costing of some of the early fuel cell work, it was done I'll have to say crudely because it was done to get reliability and to just do something, whereas there was orders of magnitudes as well.

The same thing applies in the gas turbine area where the development of gas turbines toward the possibility of becoming economically viable for the automobile really builds on aerospace.

Mr. DAVIS. Let me comment briefly on that too. From the standpoint of materials that are used in the automobile today, the automobile is a much lighter weight which improves fuel efficiency and that is largely due to the use of composite materials and plastics in cars today.

There is a tradeoff there and one tradeoff is the ability to recycle those materials which is made more difficult but of course the gains in fuel efficiency are extremely important.

Mr. LLOYD. Could I also add something? I think we've talked here about the potential of the aerospace industry and some of the engineers getting involved with this business. I heard some comments here to say well, that's going to be an easy task and I agree, but on the other hand, I think again these are skilled people, they can adapt to that.

Also, I think it's important, that somewhere there is an overlying theme here that the President's vision of this clean car is getting diluted. Nothing is going to be easy and when we look at all the barriers here, we talk about the legal barrier and I think it is time for us to turn that around and look at the entrepreneurial spirit and ask the attorneys, how can we do it, not what's stopping us from doing it.

I run into some of this in contracts. We need to look at ways of facilitating this. There is no technical reason why this can't be accomplished. If we sit around trying to dilute these dollars, looking at all the problems, we're never going to advance, we're never going to be in the position as Mr. Walsh says to compete in the national and international market.

Senator KEMPTHORNE. Mr. Chairman, as I yield back to you, I might just make a comment. Part of the solution may also be reform in the area of product liability.

Thank you.

Senator LIEBERMAN. You and I agree on that. I have a feeling it's not unanimous among the members of the committee, however, but there is a product reliability reform bill that's working its way through the Senate and I think we have a reasonably good chance of passing it this year.

Thank you, Senator Kempthorne.

I just have a few more questions. Mr. Sobey expressed some reservations about joint R&D in the industry insofar as drawing from the same technology base innovation might be inhibitive, if I'm paraphrasing it correctly.

I wonder how others on the panel feel. Mr. Lloyd, do you have a reaction to that?

Mr. LLOYD. I think what Mr. Sobey is talking about, if the older companies are all drawing on the same pool of talent and cooperating in some areas, I think there could be dangers there. I think, however, we know enough about those dangers that we should be able to frame a program whereby that can be ameliorated or in fact done away with.

I think it's very important that in fact we, in these times of limited resources, put all the talent together, pool our resources where necessary. We talked about coupling with the national labs, but again, that should be done to expedite the process, not to slow it down. I think clearly the competitive marketplace is very important to keep that out there because you're going to need competitive products there will be differences, but some of the basic technology science will be common to these and then it makes sense to cooperate, but when it gets in the marketplace, we need to encourage competition.

Senator LIEBERMAN. Mr. Sobey, part of the problem here is what you cited, the enormous capital required for some of these developments which draws the companies out of necessity to pool their resources. Do you think it's a bad idea, for instance, that the big three automakers are cooperating in the development of an electric car?

Mr. SOBEY. No, I really don't. I parallel what Alan just said. The things that are basic research and development in terms of the fundamental sciences, I think there is a great deal of commonality. When you begin to get a product is where I'm concerned.

In the case of the electric car, as it stands today looking at its market potential, it has a fairly small niche as I see it. The only way I see that can be done economically may be as some sort of a joint venture. They may have different sheet metal on the outsides, but the underlying technology may have to be the same to make it justifiable.

Senator LIEBERMAN. Let me go back to Michael with a question. I'm curious how the German automakers are responding to the proposal in Germany that the European Community adopt standards that are roughly equal to California's standards?

Mr. WALSH. I think it's safe to say, Senator, there are no volunteers. It was striking to me though in the recent development of

standards in Europe, how the German vehicle manufacturers were much more progressive and much more supportive of the today standards in Europe than some of their competitors in Europe. I think as a generalization, I would characterize them as more interested in low emission vehicles and perhaps partly for the reason that Mr. Davis pointed out. The image of the clean vehicle is very important in the German market, so I think that is another factor that influences them. I don't think anyone is quite volunteering yet.

Senator LIEBERMAN. Let me ask you a final question which is of local interest in Connecticut. Reading the New York Times yesterday which projected a loss of as many as 2 million jobs in the next 5 or 6 years from reductions in defense spending, I'm naturally interested—and I think all of us should be—we're worried about the national economy and the potential to convert some of that industry to this, to what we're talking about.

I'm interested in hearing why the two of you who I believe mentioned this, Mr. Sobey and Mr. Lloyd, why you think the defense industry is well-suited for that conversion, that transition?

Mr. SOBEY. Let me just make a couple of comments with respect to that. There are some cultural problems but the fundamental problem really has to do with the expertise of the people who are involved. There is absolutely no question that within the aerospace industry, there is a tremendous scientific pool and we need it.

On the other hand, when you get to the automobile industry itself, it is a middle technology business. Ten percent of the graduate engineers in the United States live within the three or four counties adjacent to Detroit.

Senator LIEBERMAN. Say that again, 10 percent of the graduate engineers in the U.S.?

Mr. SOBEY. Right. Those are the engineers at the baccalaureate level. Alan has a near monopoly on those who have gone to Ph.D.s and beyond, a very different culture. The automobile companies you think of, GM, Ford and Chrysler, make up well less than half of the industry. The bulk of the industry is actually in very small companies that provide special services to the automobile companies. Over half of them employ less than 200 people. They are based on the ability to find niches, expertise, and special services. They are not high tech services. They are by the blacksmith standards, but they are not by aerospace standards. They have the expertise that I really worry about saying more than the big three. Those people are the key to our automobile industry.

Senator LIEBERMAN. Mr. Lloyd?

Mr. LLOYD. We already have a program in California, CALSTART, which is basically doing just what you're stating and that is to look at how the aerospace industry and others can in fact address the components, not trying to duplicate what Detroit is doing in terms of building automobiles, but looking at the component side. There are major opportunities there and we have people like Hughes, Allied Signal, Lockheed, who are involved with that. I see no reason why that can't continue. You do have a skilled base; yes, there are differences, but in fact, if we look at new powerplants, if you look at new components, if you look at the smart cars, et

cetera, the electronics there, there is major opportunities for that to continue.

Yes, there will be a transition period, but again I think you come from the side of it, there's nothing inherently unreasonable that can't be accomplished here. We need that focus; we obviously need a commitment; we need to rethink some of these areas. If we don't, then in fact we're not going to attain what the President wants to do. So I think it's a matter of commitment. Programs can be set up for retraining, there can be this dialog. As I say, in California through CALSTART, we're already starting that process and doing it successfully, I might add.

Senator LIEBERMAN. Well, that's a good optimistic note on which to end the hearing. I take from this testimony which you've give, which has been excellent, a general note of opportunity and encouragement. We've come a long way already; there's an enormous challenge; there's a need to do this from the point of environmental protection, but there is a tremendous economic opportunity here. It's also obvious that Government and the private sector have to work together because this is critical to our economic well-being.

It's very encouraging, for instance, to hear, Mr. Smith, what you folks are already doing. We wish you well in that.

We're going to keep the record of the hearing open for an additional two weeks should any of you or anyone else want to submit additional testimony. The prepared statements that you have submitted to the committee will, of course, be included as part of the record.

I thank all of you for coming the various distances you did. The hearings will continue as I indicated at the outset and the subcommittee hopes to play a constructive and supportive role in bringing us to and by this next frontier.

Thank you all very much.

The hearing is adjourned.

[Whereupon, at 11:20 a.m., the subcommittee adjourned, to reconvene at the call of the Chair.]

[Statements submitted for the record follow:]

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TESTIMONY BEFORE THE SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR REGULATION

APRIL 27, 1993

Good morning, Mr. Chairman, and members of the Committee. My name is Michael P. Walsh and I am an independent technical consultant in the field of motor vehicle pollution control. During much of your deliberations leading up to the adoption of the 1990 Clean Air Act Amendments, I was a consultant to the Senate Environment and Public Works Committee and have worked closely with several states, especially California and the Northeast in the implementation of this critically important law. Most of my current work is overseas and I am actively involved in projects in Manila, Sri Lanka, Bangkok and China at the present time. I am also the Chairman of the External Advisory Panel to the World Bank and the Mexican Government on the Mexico City Motor Vehicle Pollution Control Project.

I am not representing anyone but myself in my testimony today. In my testimony, I would like to emphasize two key points:

1. **Future continued growth in the global automobile industry is dependent on its ability to build clean, efficient vehicles, and**

2. **Those companies which will be most successful in meeting that market demand will be those which produce highly efficient (low CO_2) and clean (low HC, NOx and CO) vehicles.**

Across the entire globe, motor vehicle usage has increased tremendously. In 1950, there were about 53 million cars on the world's roads; only four decades later, the global automobile fleet is over 430 million, more than an eightfold increase. (See Figure 1) On average, the fleet has grown by

FIGURE 1: GLOBAL TRENDS IN VEHICLE REGISTRATIONS

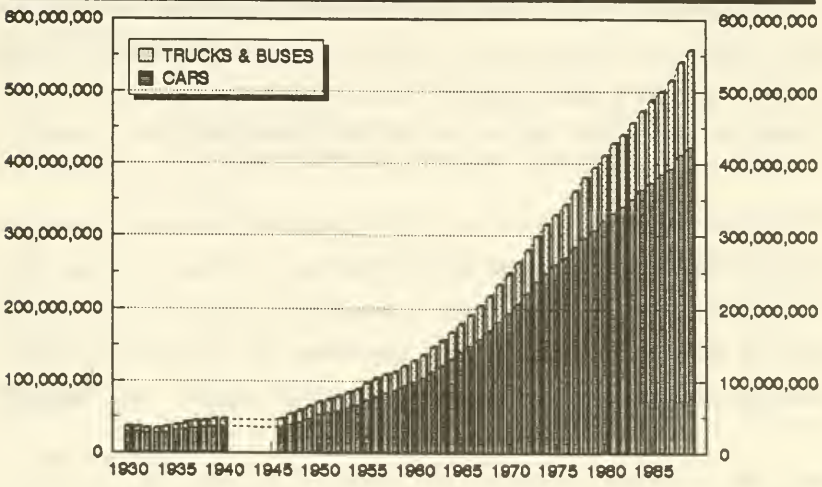
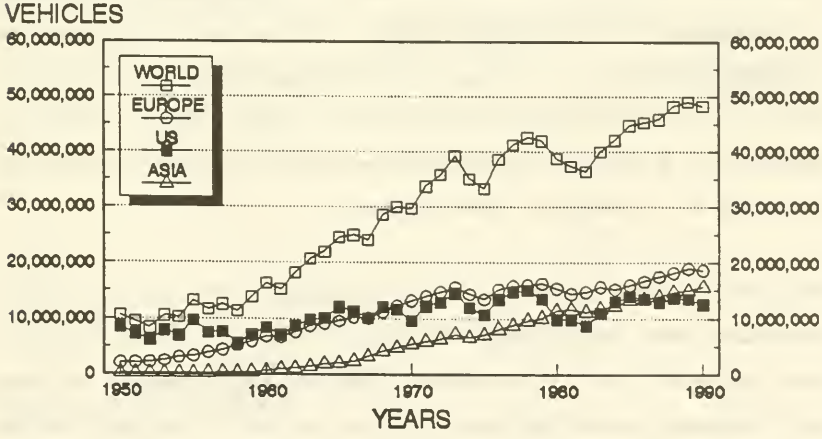


FIGURE 2: WORLD MOTOR VEHICLE PRODUCTION
1950-1990



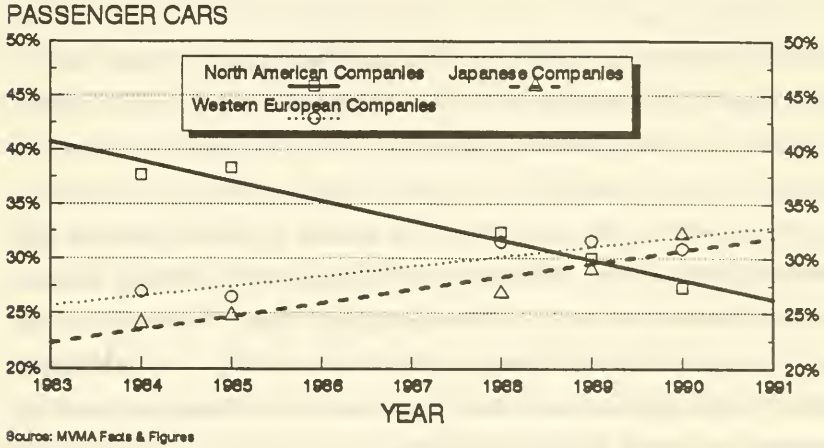
about 9.5 million automobiles per year over this period. Simultaneously, the truck and bus fleet has been growing by about 3.6 million vehicles per year. While the growth rate has slowed in the highly industrialized countries, population growth and increased urbanization and industrialization are accelerating the use of motor vehicles elsewhere.

Overall growth in the production of motor vehicles, especially since the end of World War II, has been equally dramatic. Between 1950 and 1990, production increased almost linearly from about 10 million vehicles per year to about 50 million per year, approximately 1 million additional vehicles produced each year compared to the year before. (See Figure 2)

Over the past several decades, motor vehicle production has gradually expanded from one region of the world to another. Initially and through the 1950's, it was dominated by North America. The first wave of competition came from Europe, and by the late 1960's European production had surpassed that of the United States. Over the past two decades the car industry in Asia, led by Japan, has grown rapidly and now rivals both those in the United States and Europe. The downward trend in the U.S. share of the global marketplace continues unabated to this day and may actually be increasing. (See Figure 3)

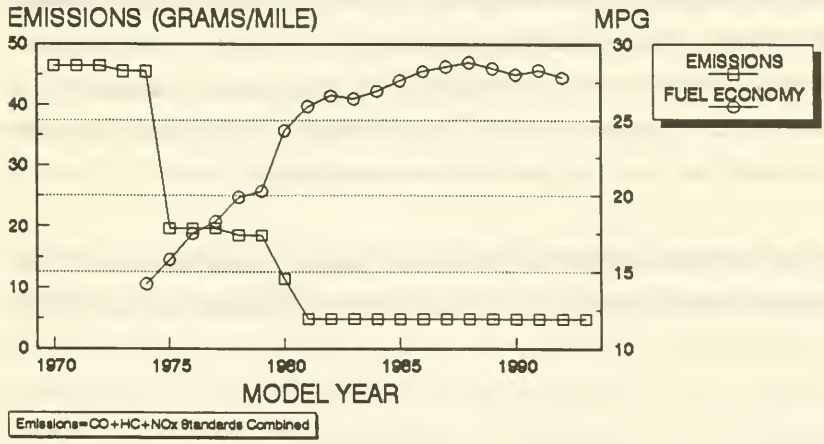
One result of the growth in vehicles and their production is that worldwide, cars, trucks, buses, and other motor vehicles are playing an ever increasing role in global climate change and air pollution. As large oil consumers, motor vehicles are major sources of carbon dioxide; volatile organic compounds (VOCs) and nitrogen oxides, the precursors to

FIGURE 3: GLOBAL MOTOR VEHICLE PRODUCTION TRENDS
COUNTRY OF ORIGIN OF COMPANIES



Source: MVMA Facts & Figures

FIGURE 4: EMISSIONS AND FUEL EFFICIENCY TRENDS
NEW CARS



Emissions=CO+HC+NOx Standards Combined

both tropospheric ozone and acid rain; carbon monoxide (CO); and chlorofluorocarbons (CFCs).

Virtually the entire global motor vehicle fleet runs on fossil fuels, primarily oil. For every gallon of oil consumed by a motor vehicle, about 19 pounds of carbon dioxide (containing about 5.3 pounds of carbon) go directly into the atmosphere.[1] In other words, for every 15 gallon fill up at the service station, about 300 pounds of carbon dioxide are eventually released into the atmosphere. Globally, motor vehicles account for about a third of world oil consumption and about 14 percent of the world's carbon dioxide emissions from fossil fuel burning. For the United States, motor vehicles cause about 50 percent of oil demand and about 25 percent of carbon dioxide emissions.

Although ozone in the lower atmosphere does not come directly from motor vehicles, they are the major source of the ozone precursors, hydrocarbons and nitrogen oxides, throughout the industrialized world. Over the past 100 years, "background" ozone levels have approximately doubled, and monitoring data suggest that ozone concentrations are increasing by about 1 percent per year in the northern hemisphere.

Besides contributing to the greenhouse problem, ozone pollution also adversely affects human health, crops, other vegetation, and materials.

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[1]Direct tail-pipe emissions only. Transportation, refining, and distribution account for perhaps 15 to 20 percent of total emissions.

Eye irritation, coughing and chest discomfort, headaches, upper respiratory illness, increased asthma attacks, and reduced pulmonary function can all plague people exposed to ozone. This gas has also been shown to reduce crop productivity, with U.S. annual losses of several billion dollars, and to kill ponderosa and Jeffrey pines in California and eastern white pines in the eastern United States.

Widespread and pervasive, smog looks to be a long term problem in many areas of the world unless more stringent controls on vehicles and other sources are adopted. Areas of rapid industrialization are now starting to note similar air pollution problems to those of the industrialized world. Cities such as Mexico, Delhi, Seoul, Singapore, Hong Kong, Sao Paulo, Manila, Santiago, Bangkok, Taipei and Beijing to cite just a few already experience unacceptable air quality or are projecting that they will in the relatively near future. Some of these cities - especially Bangkok, Mexico City, and Athens stand out - are already in crisis with alarming levels of pollution a daily reality. As the vehicle population has grown and become increasingly concentrated in the world's growing number of megacities, the number of people subjected to unhealthy levels of pollution continues to rise.

Fortunately, advances in automotive technologies have made it possible for countries to respond to these health and environmental concerns by dramatically lowering emissions from motor vehicles. Increasingly, countries around the world have been taking advantage of them. Initial crankcase HC controls were first introduced in the early '60's followed by exhaust CO and HC standards later that decade. During the mid to late

1970's, advanced technologies including catalytic converters were introduced on most new cars in the U.S. and Japan. These technologies resulted from a conscious decision to "force" the development of new approaches and were able to dramatically reduce CO, HC and NOx emissions beyond previous systems. As illustrated in Figure 4, at the same time that pollution levels were being reduced, vehicle fuel economy doubled. U.S. industry can and should take great pride in the fact that new cars produced in the U.S. today emit but a small fraction of the pollution that they did a generation ago for each mile they drive and consume only half the volume of fuel.

With knowledge of these technological developments on cars spreading, and the adverse effects of motor vehicle pollution becoming more widely recognized, more and more people across the globe began demanding the use of these systems in their countries. During the mid 1980's, Austria, the Netherlands and the Federal Republic of Germany adopted innovative economic incentive approaches to encourage purchase of low pollution vehicles. Australia, Canada, Finland, Austria, Norway, Sweden, and Switzerland all decided to adopt mandatory requirements. Even rapidly industrializing, developing countries such as Brazil, Chile, Taiwan, Hong Kong, Mexico, Singapore and South Korea have adopted stringent emissions regulations. After years of delay, the European Economic Community has begun to move rapidly toward state of the art pollution controls. As 1990 came to a close, the European Council of Environmental Ministers reached unanimous agreement to require all new models of light duty vehicles by 1992/1993 to meet emission standards roughly equivalent to current U.S. levels. Further they voted to require the Commission to develop a proposal

which, taking account of technical progress, will require a further reduction in limit values. (Figure 5 and 6 illustrates that most major countries of the world and many rapidly industrializing ones have or are moving toward U.S. type auto emission standards.)

Just as the world was catching up with the U.S. auto standards, the U.S. and California during 1990, decided to push technology toward the next generation of controls. (See Figures 7 and 8) As California's standards are much more stringent than Federal requirements and mandate the development of Zero Emission vehicles (so called ZEV's), many other states with serious air pollution problems have decided to opt into the California program. (See Figure 9)

On a technological level, the response to California's requirements has been tremendous. For example, just about a year ago, on April 14, 1992 Ford Motor Company announced that the 1993 model Ford Escort and Mercury Tracer powered by a new 1.9 liter engine "achieved a major milestone, four years ahead of schedule, making it the first auto maker to meet the first in a series of very stringent air quality standards adopted by California for the 1990's." As Ford further noted, "the engine in these vehicles was designed and is manufactured in the United States, using U.S. components". EPA has also tested a 2 stroke engine manufactured by Orbital engine company and found it to have exceptional fuel economy while virtually achieving California's Ultra Low Emission Levels. In addition, tremendous advances in electric vehicles and fuel cells are starting to emerge in response to California's specific mandate for 10% Zero Emissions Vehicles by early in the next century.

FIGURE 5: ASIA PACIFIC REGION

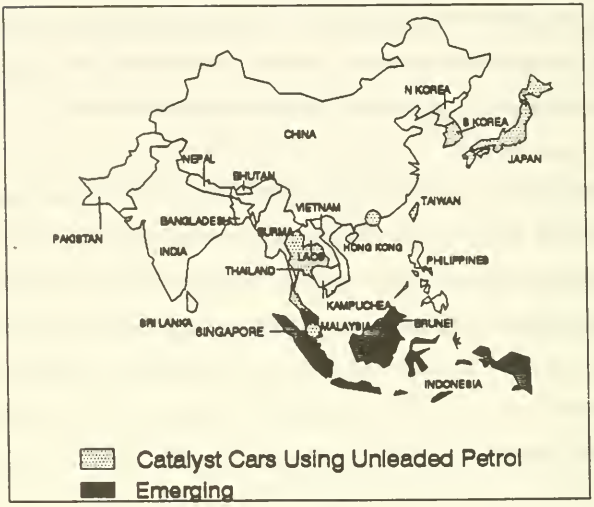
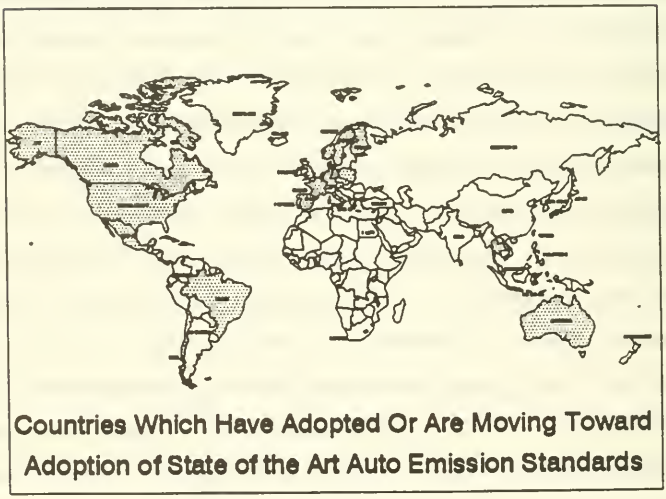


FIGURE 6: WORLDWIDE OVERVIEW



Countries Which Have Adopted Or Are Moving Toward Adoption of State of the Art Auto Emission Standards

FIGURE 7: AUTO AND LIGHT TRUCK STANDARDS IN USE

OXIDES OF NITROGEN

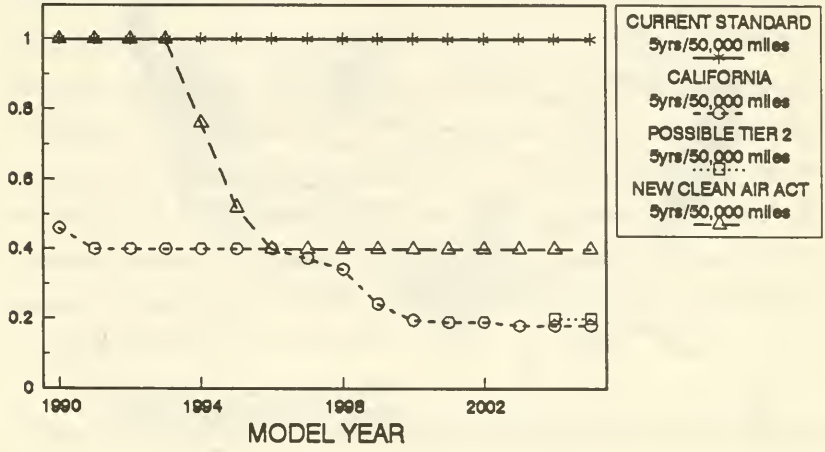


FIGURE 8: AUTO AND LIGHT TRUCK STANDARDS IN USE

HYDROCARBONS

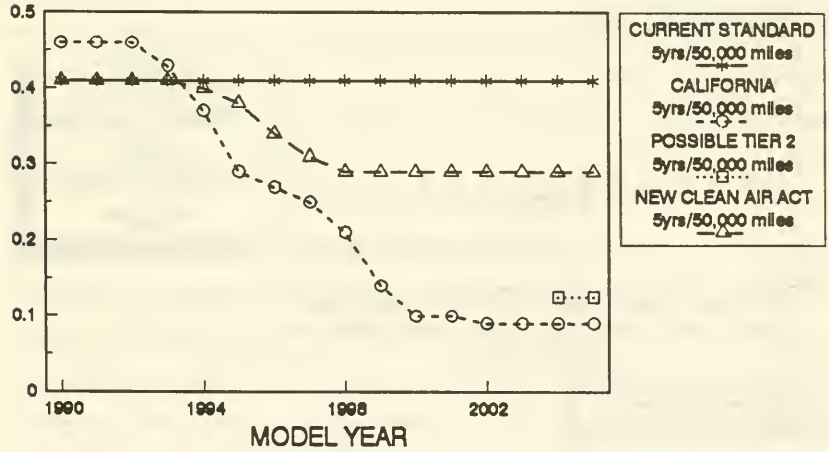


FIGURE 9: MOVEMENT TOWARD "CALIFORNIA" STANDARDS

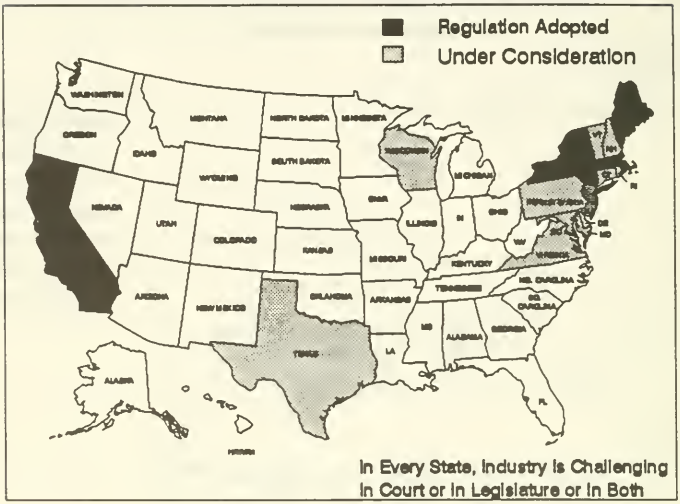
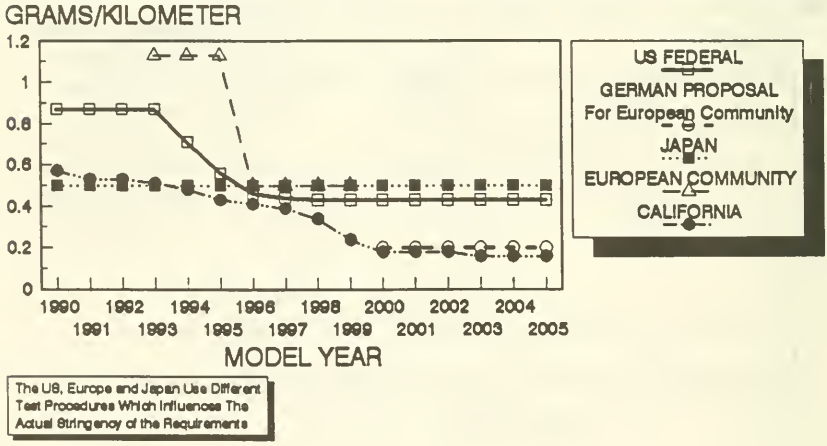


FIGURE 10: CURRENT LIGHT DUTY VEHICLE STANDARDS

HC PLUS NOx COMBINED



The US, Europe and Japan Use Different Test Procedures Which Influences The Actual Stringency of the Requirements

Ironically, while the technology continues to advance, and the domestic car industry has publicly reacted very positively to President Clinton's Green Car initiative, they continue to aggressively oppose these state efforts in the Courts and in State legislatures. This is especially puzzling and troubling because the development of these clean vehicle technologies would tend in my view to give the domestic vehicle industry a leg up on the rest of the world, as the rest of the world follows the U.S. and California toward tighter standards. This is already beginning. For example, Germany has proposed that the entire European Community, the largest car market in the world, adopt standards similar to California's by the year 2000. (see Figure 10)

In looking to the future motor vehicle marketplace, two trends stand out. First, it is expected that continuous high growth in vehicle production will remain the norm, at least for the next several decades as countries with much lower per capita vehicle populations advance economically. The major threat to this growth in new car sales, in my judgement, is the serious environmental problems which they cause. In effect, therefore, the future of the automobile industry is dependent on its ability to build clean, efficient vehicles.

Thus the second conclusion that those companies which will be most successful in meeting that market demand will be those which produce highly efficient (low CO_2) and clean (low HC, NOx and CO) vehicles. With European and other countries committed to stabilization of CO_2 emissions (See Figure 11), the demand for more fuel efficient vehicles

FIGURE 11: WORLDWIDE OVERVIEW

Countries Which Have Adopted Or Are Moving Toward Stabilization In Carbon Dioxide Emissions

will continue to increase. Further, as pollution problems become more severe in the rapidly developing countries, they are increasingly moving toward stringent control of conventional pollutants. In order to compete successfully, car companies of the future will need to produce efficient, clean vehicles. If U.S. companies aggressively pursue this market, it will lead to more jobs and greater profitability. Conversely, those which cannot or choose not to compete in this aspect of the market will fall further and further behind. As an aside, it should be noted that clean vehicles by contributing to clean cities will also improve those economies by reducing the costs of pollution.

TESTIMONY ON THE CLEAN CAR TASK FORCE

Presented Before the United States Senate

Committee on Environment and Public Works

Subcommittee on Clean Air and Nuclear Regulation

Washington, D.C.

April 27, 1993

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TESTIMONY ON THE CLEAN CAR TASK FORCE

This testimony addresses the proposed efforts of President Clinton's Clean Car Task Force. It is structured to provide background on the magnitude of air quality problems in the Los Angeles Basin, with specific emphasis on how motor vehicles contribute. Perspectives are offered about technology development based on the South Coast Air Quality Management District's small but effective program. Recommendations are provided on the thrust of this program and its ability to provide world leadership and global sales for the automobile industry.

This testimony comes directly from the District's experience with forcing development of advanced technologies through standards and deadlines. However, we have put equal emphasis on our responsibility to help develop the needed technologies. I oversee the District's $7 million per year technology advancement program, which has cumulatively supported more than 75 demonstration programs since 1988. We have been able to leverage each of our dollars with about three outside dollars from industry, academia, state and national agencies, and other sponsors. We are pleased to see the new interest here in Congress and at the White House to launch a much-needed Clean Car Task Force. Drawing on my experience, I offer the following information and responses to your specific questions about how to set up a large national program in cooperation with the auto industry.

Introduction

Motor vehicles are the major source of air pollution in America's urban areas. The South Coast Air Quality Management District (the District) is very supportive of the idea proposed by the Administration to develop new and progressively cleaner power-plant technologies for the automobile. At stake is not just healthful air and better quality of life in our cities, but also restoration of the U.S. auto industry's world leadership.

Since the introduction of the California Low Emission Vehicle/Clean Fuel (LEV/CF) Program in 1990 by the California Air Resources Board (CARB), there have been dramatic advances in automotive emission control technologies and clean-burning alternative fuels, including electricity and hydrogen. We applaud the efforts and accomplishments of the automobile and emissions control industries

leading up to, and subsequent to, adoption of this revolutionary program. To date, the LEV Program has been a major catalyst for substantial worldwide research and development, which has resulted in greater than anticipated progress towards the ultra-low and zero-emission vehicles.

We see the proposed Clean Car Task Force as an important and unprecedented opportunity for the U.S. auto industry to leapfrog current vehicle technology and provide the type of leadership for which it was once recognized. Our agency has not just the desire -- but the undeniable need and obligation as well -- to rapidly deploy advanced zero-emission vehicles using non-combustion propulsion systems such as fuel cells and advanced batteries. To illustrate this need, I will provide a brief background on the description of the Los Angeles area, its ambient air quality, and the health impacts faced by the citizens of this region.

Scope of the Air Pollution Problem in Southern California

The South Coast Air Basin (Basin) is a 6,600 square-mile area bounded by the Pacific Ocean to the west and the San Gabriel, San Bernardino, and San Jacinto mountains to the north and east. The Basin includes all of Orange County and the non-desert portions of Los Angeles, Riverside, and San Bernardino Counties.

The Basin currently is home to more than 13 million people and 9 million motor vehicles. These vehicles are driven about 280 million miles each day, which explains how this relatively small area has become the world's largest gasoline market. The pollutants that pour from these on-road motor vehicles in staggering amounts are cooked in Southern California's abundant sunlight, with the effects intensified by topographical features and a climate that are highly conducive to air pollution formation. Summer months are typically characterized by an inversion layer that inhibits the upward dispersion of air pollutants, trapping them. In addition, calm breezes further limit ventilation and air mass mixing. The result is a virtual photochemical smog factory and America's most unhealthful air.

The Basin's principal air pollution concern is ozone, and the precursor emissions come largely from motor vehicles. On- and off-road motor vehicles contribute approximately 50% of the reactive organic compounds (ROC) and 75% of the oxides of nitrogen (NO_x). In addition to its ozone nonattainment status, the Basin is

also significantly above standards for carbon monoxide (CO) and fine particulate matter (PM_{10}), of which more than 90% and 6%, respectively, come from these vehicle categories. Finally, these vehicles emit carbon dioxide, methane, and nitrous oxide, all of which contribute significantly to global climate change.

While significant emissions reductions from all sources are needed to restore healthful air in the Basin, the key lies in rapidly developing much cleaner modes of transportation. We believe that such a strategy makes economic as well as environmental sense. A recent study conducted for the District by California State University found that the annual cost of the Basin's poor air quality -- just in terms of adverse human health effects -- is at least $9 billion.

Since the end of World War II, the Basin has experienced faster population growth than the rest of the United States. Although growth today has slowed somewhat, the region's population will continue to increase significantly. By 2010, it is estimated that the Basin's population will be approximately 18 million, representing about a 35% increase from current levels.

As the result of effective emission controls, per capita emissions have been brought down substantially in the Basin. In particular, progress in lowering emissions from new automobiles has been encouraging, thanks to California's 25-year history of technology-forcing regulations and the automotive industry's successful response to them. However, increases in the Basin's population and vehicle trips over that time have made significant overall emission reductions more difficult. Increases in the number of sources, particularly those growing proportionately to population, reduce the potential air quality benefits of new controls. The net result is that unless dramatic steps are taken to control air pollution at a much faster rate than ever before, growth will overwhelm the improvements expected from the existing control programs. In terms of mobile source control strategies, the Basin must have a wide influx of non-polluting vehicles over the next 15 years.

The District's Air Quality Management Plan

The District, as the regional regulatory body with responsibility for air pollution control in the Basin, is developing and implementing the world's most comprehensive air quality management plan for stationary and mobile sources. The

District is responsible for establishing and enforcing regulations for stationary sources and is actively involved in research to advance control technologies in this area, including several related to fuel cells and other advanced technologies. Efforts to control Basin vehicular air pollution are directed and enforced by state, regional, and local agencies, with the District responsible for the overall clean up plan. The District also funds, either partially or fully, mobile source research in emission controls and alternative fuels technologies for both on-and off-road categories. This funding includes numerous projects to research, develop, and demonstrate vehicles powered by fuel cells and storage batteries.

In cooperation with the state and local agencies, the District has taken a comprehensive approach to reduce the impact of vehicular emissions. Goals of this strategy include: enforcement of existing standards; implementation of broader, more stringent emission standards; continued promotion of clean fuel vehicles and low-emissions technology; and an increased emphasis on transportation control measures.

The CARB LEV/CF program is the foundation for California's long-term plan to clean up mobile source emissions. For the lighter vehicle classes, four standards levels have been defined by the CARB. Vehicles types based on the four standards levels, in order of increasing stringency, are transitional low-emission vehicles, low-emission vehicles, ultra-low-emission vehicles, and zero-emission vehicles (ZEV).

In addition to sales-weighted non-methane organic gas (NMOG) standards that take effect in 1994, the CARB regulations established a revolutionary mandate for ZEV sales. In 1998, two percent of each major manufacturer's sales for passenger cars and light-duty trucks must be ZEVs. In 2003 and subsequent model years, ten percent of sales of these vehicle classes must be ZEVs. At this time, only battery-powered electric vehicles and pure-hydrogen fuel cell vehicles will meet the ZEV definition.

It is anticipated that California will, in the near future, consider low-emission vehicle regulations for heavy-duty vehicles and urban buses. In addition, emission limits for California off-road vehicle classes such as construction and farm equipment, utility equipment, marine vessels, and locomotives are under consideration.

Responses to Questions

1. **How can the work of the Clean Car Task Force, recently established by President Clinton, and other industry and public initiatives, assist in developing approaches that will help ensure that the requirements of the Clean Air Act Amendments of 1990 are met?**

The Clean Car Task Force offers a significant opportunity to pool the technical and strategic resources of the private and public sector. To best ensure that this Task Force reinforces the Clean Air Act requirements, as well as the Energy Policy Act, a process should be established to include the maximum input from California air pollution and energy regulatory bodies. The following are specific suggestions in this regard.

Recognize California's Leadership

The program should formally recognize the California LEV/CF and ZEV program as the central point of departure for an environmentally sound renaissance of American auto manufacturing. There is no need for the federal government to re-invent or delay these technology milestones.

Build on the California Program

The pace of design, development, demonstration and commercialization of all LEV and ZEV technologies needs to be expedited and augmented. One consideration may be to introduce another LEV category such as a hybrid electric vehicle (HEV) category, whose requirements would lie between a ULEV and ZEV. This would provide the incentives for producing HEVs without compromising the integrity of ZEVs. Also, by expediting compliance with the California timetable the federal government can maximize the potential "spill-over" benefits for other states such as New York and Massachusetts.

2. What other environmental benefits can result from developing cleaner cars?

The environmental benefits of more efficient, cleaner cars powered by alternatives to petroleum will have far-reaching effects that go well beyond immediate health concerns. For example, greater use of alternative fuels like natural gas and methanol -- initially in internal combustion engines, and subsequently as hydrogen sources for highly efficient fuel cells -- will substantially reduce the environmental exposures associated with extraction, transport, and storage of gasoline and diesel fuel. A comprehensive approach to clean cars will lead to vehicles with high efficiency and fuel economy, the lowest possible cradle-to-grave emissions including global warming gases, no stratospheric-ozone-depletion gases, and a high percentage of recyclable parts. In the end, however, we must get to true zero emissions vehicles running on renewable electricity or solar-generated-hydrogen fuel cells. If we do not find a way to do so, we may lose the luxury of personal mobility as we know it.

3. What impediments, if any, exist to designing and producing cleaner cars? How can these impediments be overcome?

There are numerous barriers which need to be addressed in commercializing low-emission and clean-fuel vehicles. One important approach to removing these barriers will be to build on the progress of California. There are several key issues which should be addressed to obtain the maximum economic stimulus from the President's initiative while reducing technological and institutional barriers.

Establish Specific Aerospace Industry Targets

The federal government should establish specific research goals, timetables and strategic targets on ZEVs that take fullest advantage of the nation's defense aerospace electronics industrial base. Numerous prime contractors and subcontractors have expertise in designing defense-oriented energy systems that can be re-focused on commercially viable zero emission technologies such as fuel cells for automotive application.

Commit Federal Funding Now

The efforts of California's CALSTART and other similar ZEV programs should receive immediate federal commitment towards technology development and commercialization programs. Major California defense contractors such as Hughes are downsizing and relocating out-of-state, due in part to a lack of federal funding for fuel cell and other ZEV technologies.

Think in Terms of Billions, not Millions of Dollars

A "big science" commitment equivalent to the super-collider is needed to address the scope of development needed to develop ZEV technologies for large market segments. By at least matching the investments of the Japanese and Europeans on long-term technology, the U.S. will have the opportunity to remain competitive in international markets. If the U.S. underinvests today in the crucial area of long-term environmental technology, we will quickly lose our ability to shape the specifications and timetables.

Establish Small Business Initiatives

Small start-up, high technology industries are likely to be the key to maximizing the job growth anticipated from the Clean Car Task Force. Government needs to expand its outreach and provide special assistance to small- and medium-sized firms, and provide major incentives to expand their businesses into these new environmental technologies. One specific element of the Clean Car Task Force should be focused exclusively on small business. While the major advances may occur through the large auto manufacturers, history teaches us that it would be prudent to provide federal risk sharing for small businesses, so that they have a funded avenue for their potential breakthrough technologies.

An Infrastructure Component is Needed

The Initiative should also recognize the critical need to expedite the establishment of an infrastructure to supply the clean fuels (such as electricity, hydrogen, natural gas, methanol, or other hydrogen-precursor sources) needed for LEV and ZEV

vehicles. If the Task Force assumes that the conventional fueling infrastructure is adequate to fully accommodate the commercialization of LEV and ZEV technology, the clean car initiative will fail.

There are major infrastructure synergies that the federal government can and should leverage. . Natural gas, and methanol derived from natural gas, have significant near-term potential to replace conventional gasoline and diesel fuels. These fuels, if made readily available today, can be used to help expedite manufacturers' efforts to develop and commercialize LEV vehicles. The key transition to bear in mind is the potential to use these fuels as hydrogen precursors. That is, these fuels can be used as a means of carrying hydrogen on-board or off-board a vehicle, for use in fuel cells. This hydrogen can then be converted electrochemically to electricity for use in powering an electric motor. A network of alternative fuel stations would significantly accelerate California's ability to introduce cleaner combustion vehicles, followed by hybrids and ZEVs, all of which could be at least as clean as ultra-low emission vehicles.

The development of a hydrogen economy may depend in part on the early introduction of easier and lower cost storage media for hydrogen, such as natural gas or methanol. The federal government therefore needs to directly augment the Clean Car Task Force with a broad-based Clean Fuel Infrastructure component.

Breakthrough Technologies Offer High Rewards

Above all, the federal government must share the risk and costs of advanced technology research and development. After all, that is the purpose of federal research support: to help fund the high risk, high reward, breakthrough technologies that have a longer term payoff than most businesses can aim for in today's short-term business world. It is these breakthrough technologies and not "business as usual" that will assure the long term health of the U.S. industry.

For example, the District was the founding member of the Ad Hoc Coalition on Fuel Cells for Transportation, which now has nearly 30 members. . We have developed a seven-year plan that relies heavily on federal purchases to stimulate the commercialization of this technology. A copy of the plan is appended to my testimony. This plan largely depends on earmarking existing federal transit subsidy

and vehicle purchase programs. The $4.4 billion cost is less than the nation pays for imported oil in a single month.

4. **What is the potential export market for clean cars and clean car technology? What factors in the design and production of automobiles will help increase American industry's share of the export market?**

In the past 15 years, foreign manufacturers have proven to be extremely adept at providing vehicles that simultaneously have good driveability, low emissions, and good fuel economy. Their gain in the U.S. market share was inevitably at the expense of domestic manufacturers. Based on the technical updates that we frequently get, foreign manufacturers are working harder than ever to gain a competitive advantage by meeting the challenges of California's LEV standards. The market in California alone consists of more than two million new vehicles each year. With many other states and countries looking to California's program with the intention of copying it, the potential worldwide market for advanced low-emission vehicles is enormous. The U.S. auto makers will compete quite well if they focus on highly efficient, progressively advanced technologies that minimize emissions of air pollutants and global warming gases, while maximizing fuel economy. The latter two qualities seem to be especially important in the European car market.

Clearly, the export potential of clean vehicles is very significant. There are several issues that will be key to strengthening U.S. leadership in the emerging international market.

Maximize the Potential for Synergies

The Initiative should also formally recognize that the development and commercialization of ZEVs is directly benefitted by expediting LEV technologies such as electrically heated catalysts, dedicated natural gas vehicles, and flexible-fuel vehicles. It is impossible to anticipate all of the creative engineering synergies which may occur between these and other technologies. Addressing long-term goals is best accomplished by ensuring that near-term progress continues and accelerates. Two examples of such synergies are the Volvo 850 "Environmental Concept Car: with a high speed turbine and battery system, and Volvo's 940 "Environmental

Impact Vehicle" which has an electrically heated catalyst with methanol flexible-fuel capability.

The First Priority Should be Expanding the Number of LEVs and ZEVs in California

There are major developments already underway to offer LEVs and ZEVs for sale in California. Indeed, the industry has been more successful and ahead of schedule than expected in meeting these standards. Ten electric vehicle models produced by four manufacturers are already certified as ZEVs in California. One Low-Emission Vehicle (LEV) is also certified on compressed natural gas. This Chrysler Dodge B350 Van is the cleanest medium-duty vehicle ever certified in California. Three methanol compatible passenger cars are certified as TLEVs (the Chrysler Spirit Acclaim, Chevrolet Lumina and the Ford Taurus). Two TLEV passenger cars are also certified on conventional gasoline, while two other car models are conditionally certified as TLEV using Phase II California gasoline. This progress can best be accelerated by careful coordination with the federal Clean Car Task Force. California's successful market launch can therefore help establish a springboard for international export activities.

Conclusions

In summary, I want to applaud the Administration for its visionary approach to leapfrogging existing technologies and providing a goal to restore America's world leadership in the auto industry. This will provide the maximum benefit to the environment both in the lower and upper atmosphere, thereby providing maximum protection for public health. At the same time, it will create a climate with unprecedented opportunities for the U.S. auto industry to expand into new automobile markets worldwide. We think it would be a major mistake to dilute efforts to address existing programs which are advancing at a significant pace. Instead, they should be expanded, and the limited federal dollars should be maximized to share risks with industry. The challenges are great, but the payoffs will be tremendous.

FUEL CELLS FOR TRANSPORTATION

Dr. Alan Lloyd
Chairman

Robert Rose
Coordinator

NATIONAL INITIATIVE ON FUEL CELLS FOR TRANSPORTATION

The National Initiative on Fuel Cells for Transportation is a seven-year plan to develop energy efficient, pollution free motor vehicles for the American marketplace by the year 2000, using hydrogen fuel cells. Fuel cells create energy without combustion, with zero emissions at up to 80 to 90 percent overall energy efficiency.

What Will the Initiative Do?

- It will create or save almost 6,000 permanent, high-tech jobs in the first year alone.
- It will support small and expanding businesses, the nation's primary source of jobs.
- It will stimulate private investment by providing markets for emerging products.
- Most importantly, it will preserve our personal mobility without the sacrifice of our environment.

How Will It Work?

- By concentrating on demonstration projects and fleet government purchases, it will get fuel cell vehicles out of the laboratory and into the marketplace quickly, and with maximum public benefit.
- The Energy Department will manage an expanded RD&D program; the Transportation Department will make fuel cell vehicle purchases part of its ongoing transit programs; Defense will support dual use technologies and purchase fuel cell products; and Commerce can play a coordinating role.

What Will It Cost?

- The federal share is $4.4 billion through the year 2000, about one month's worth of imported oil.
- Industry will carry an increasing share of the cost as the technology matures. This is one way to implement President Clinton's proposal to provide "patient capital" to revitalize the US technology base.

The Ad Hoc Coalition on Fuel Cells for Transportation
901 15th Street, NW #570 Washington, D.C. 20005
(202) 371-0764 Fax (202) 371-0355

Can We Afford It?

- Yes. Most of the money will come from current fleet and transit purchase programs, the rest from reordering priorities at the Departments of Defense and Energy. DOE's nuclear weapons program, for example, cost $12 billion in 1993. The $40 million we advocate to advance transportation fuel cell technologies represents less than two days spending for the weapons program.

- The initiative is in line with President Clinton's plan to develop a Clean Car using fuel cells, and with the Defense Reinvestment program developed by Congress in 1992 and expanded by President Clinton in 1993.

- It would fully implement the National Energy Policy Act, which set the nation's energy agenda in 1992.

What Are the Benefits?

- Transportation causes more pollution than any other single source, creating nearly 100 million tons of pollution a year. Fuel cell vehicles are the only truly "zero emission" vehicles.

- Passenger vehicles alone consume more than 6 million barrels of oil every day, equivalent to 85 percent of oil imports. Fuel cell vehicles are three times more fuel efficient than conventional vehicles.

- Vehicles create one-fourth of the nation's emissions of carbon dioxide, the key to global warming. Fuel cell vehicles will reduce carbon dioxide emissions dramatically.

- Fuel cell vehicles will enable the nation to use renewable energy such as solar and wind power for transportation, creating true zero emission systems.

What if We Don't Act?

- If nothing is done, pollution and declining oil supplies will restrict and ultimately choke off economic growth and impose an increasing health burden on our cities.

- Energy is one of the world's primary economic battlegrounds. Our national security depends on our developing, utilizing, and exporting technologies that produce energy with maximum efficiency and minimum environmental cost. The U.S. lead in fuel cell technology is eroding; we face competition from Europe, Japan and Canada.

Aren't Fuel Cells a Long Way Off?

- Fuel Cell Vehicles are <u>not</u> a far distant technology. Fuel cells have been utilized in stationary and mobile applications. Fuel cell buses can be ready for the marketplace by 1995, given adequate funding and incentives.

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Office of the Chief Scientist
Alan C. Lloyd, Ph.D.

May 7, 1993

The Honorable Dirk Kempthorne
United States Senate
Dirkson 367
Washington, D.C. 20515

Dear Senator Kempthorne:

I wanted to elaborate upon my remarks on ethanol in response to your questions at the Senate Subcommittee Hearing on April 27, 1993. My remarks with respect to ethanol were based on the assumption that the fuel we were discussing was E-85, which I have come to believe has potential as a clean fuel. I was not talking about ethanol used as a blending agent to increase oxygen into the fuel. This issue has received considerable debate, and has raised concerns about the volatility increase in gasoline. For example, if gasohol containing neat ethanol is commixed with reformulated gasoline, there will be an increase in evaporative emissions even though each fuel complies separately with applicable volatility requirements at the point of sale. I agree with the concerns expressed regarding that issue.

You should be aware that one of the Department of Energy's fuel cell buses, with delivery expected later this year, will run on ethanol as a source of hydrogen. This bus will have an ethanol reformer on-board to generate the hydrogen, which will then be used in the clean fuel cell. The other buses will be using methanol. This proof-of-concept vehicle should demonstrate that ethanol can be used, in a clean sense, as a fuel to hydrogen fuel cells.

If you have any additional questions, please feel free to contact me at: (909) 396-3245. It was a pleasure to have the opportunity to address the Subcommittee.

Sincerely,

Alan C. Lloyd

Alan C. Lloyd, Ph.D.
Chief Scientist

ACL:dk

cc: Senator Joseph Lieberman
Joyce Rechtschaffen

TESTIMONY FOR SENATE HEARING
SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR REGULATION
OPPORTUNITIES TO REDUCE
AUTOMOTIVE EMISSIONS
Albert J Sobey
April 27 ,1993

Thank You Senator Liebermann:

I appreciate this opportunity to discuss ways to reduce automotive emissions and describe some problems a "Clean Car" initiative may face. The comments I will make are my own. They do not represent any single or group of companies or organizations.

They are based on my recent contacts with people in the automotive industry and government, as well as my prior experience which included; directing research on aircraft engines and rockets, managing demonstrations of innovative cars and transportation system equipment, founding and serving as President of a company which builds transportation systems and a cosponsor of the Automotive Industry Small Supplier Forum.

Since retiring from GM, in 1987, where I last was Senior Director of Energy and Advanced Product Economics, I have been a consultant to several California agencies on transportation and energy, to the U.S. Department of Energy on Commercialization of Fuel Cells and to other companies and organizations interested in transportation or energy innovation.

This experience provides an insight into the potential for - and the problems of - introducing new transportation concepts, from both the pubic and private viewpoints. I will discuss several ways to reduce emissions from cars. But if they are to be successfully implemented, we must also find ways to minimize what I call - the non technical barriers.

The letter describing this hearing identified the following questions which are to be addressed

- *How can the work of the clean car task force, recently established by President Clinton and other industry and public initiatives, assist in developing approaches that will help insure that the requirements of the Clan Air Act Amendments of 1990 are met?*

- *What other environmental benefits can result from developing cleaner cars?*

- *What impediments, if any, exist to designing and producing cleaner cars?. How can these impediments be overcome?*

- *What is the potential export market for clean cars and clean car technology?. What factors in the design and production of automobiles will help increase American industries's share of the export market?*

It appears that the intent of the "Clean Car" initiative outlined in the Clinton, Gore report of February 22, 1993, is to go beyond the amendments of the clean air act to determine how to achieve the lowest practical level of noxious emissions and to reduce the generation of carbon dioxide and green house gases, in the least time at the lowest societal cost.

While the emphasis of the "Clean Car" initiative is on propulsion, the automobile is only one element of the personal transportation system. The infrastructure, roads, freeways, traffic controls all influence the generation of emissions, as does use of public transit. There are environmental implications at every stage from production of raw materials, production of fuels, design and manufacture of cars as well as their operation and disposal. I will concentrate on propulsion, vehicle concepts and the barriers to innovation.

First - What are the Opportunities for Developing "Clean Cars" or near "clean cars"?

The emissions from automobiles may be reduced by:

1. Improving propulsion systems
2. Reducing power requirements
3. Changing the way people use cars

There is still some potential for reducing the noxious emissions from piston engines - but it is limited. This is an area where invention is still possible - unlike efficiency, where the best piston engine designs are approaching the theoretical limits of the second law of thermodynamics or the "Carnot" limits.

Automobile engine researchers indicate that significant reductions in the emissions from piston engines will be difficult, expensive and involve devices or gadgets which have questionable life. It seems that we are near

the practical limits of improvements to the piston engine. Even utility powerplants seldom exceed 50% efficiency. Their emission control devices can be a major share of the total cost of the powerplant.

The automotive industry, in cooperation with energy companies, has been developing specifications for "reformulated" gasolines which reduce the emissions of piston engines. They and alternative fuels like natural gas and methanol, can provide some near term benefits, if they are used in existing engines. The linkage between the engine design and fuel characteristics will be increasingly important in the future.

The energy companies have to take a longer view than the automobile companies. Their investments in refineries, pipelines etc. are planned for the better part of a century, not several model years. They have to plan for an uncertain future. Billions of dollars of investments may be wiped out by changes in fuel requirements or engine types.

The lowest emission piston engines will be those fueled with hydrogen. They will still generate NOx. Hydrogen may be an ideal fuel - in the engine - but it is anything but an ideal fuel to transport and store in an automobile. Hydrogen will leak (seep) through anything and causes embrittlement of metals. When viewed as a total system I suspect that reforming methanol or natural gas, on the car, to generate hydrogen will have technical and economic advantages - but we do not have enough economic information to confirm this.

The "new" propulsion systems which should be considered for use in near "clean cars" include:

- o Gas Turbines
- o Stirling engines
- o Battery Electric
- o Fuel Cells

Gas turbines are excellent aircraft engines - but early automotive turbines were at a disadvantage because their efficiency falls off rapidly as power is reduced. Automotive companies: GM, Ford and Chrysler have spent large amounts of money on gas turbines - with no successful products to show. The recent development of high temperature ceramic turbines (by DOE contractors) indicates that gas turbines can; be competitive in fuel consumption, meet California's Ultra Low Emission Standards and - while still not confirmed - be priced competitively.

The stirling engine is an external combustion engine. It should have the lowest emissions of any thermal power plant. GM and Ford both had large stirling engine propulsion programs - which came to naught. GM built a "zero emission" stirling powered car which ran off stored thermal energy.

Unfortunately the first generation of stirling engines, based on a design by Phillips was expensive and had mechanical problems. A recent design by Stirling Thermal Motors, of Ann Arbor Michigan, appears to have solved these problems. Detroit Diesel Corp. is planning to offer a small stirling engine for sale at about the same price as a comparable diesel.

Use of thermal engines will usually generate carbon dioxide, if not in the engine, during fuel processing. Carbon dioxide neutral fuels from renewable energy resources are being developed, but it is probable that the oil producers (OPEC) will be able to undercut their costs, if they want to discourage their use, for decades.

Battery electric propulsion appears to be one way to create a "clean car". But, except for some niches, which I will get to later, it appears unlikely that battery cars can compete, in range or costs, with chemically fueled cars. I understand why the general public would expect a "battery breakthrough". But most engineers know how low a probability this is, they were exposed to the electrochemical series in school. It defines the theoretical limit to the energy which can be released by batteries. I directed research on high energy batteries under contract to NASA. They used materials which I would not want in my car and they still were far short of the performance required for a car.

The size of the market for battery electric cars will depend on how many people, who can make their daily trips, reliably, within the practical range of available batteries (30 to 60 miles with existing batteries), will find the benefits sufficient to overcome their cost and range deficiencies. The benefits may include: avoiding the hassle of going to a filling station, ease of starting and reliability. There is no experience to use to determine whether industry can bank on this market - or whether the benefits are illusionary. We need real world research, demonstrations of how people will actually use them. The demonstration cars should have the same feel and finish as that people expect, and be used for a long enough times to overcome the novelty effects.

This leaves Fuel Cells - which have become fashionable lately. I have long been an advocate of fuel cells. I believe that they will ultimately be the propulsion system of choice for all ground vehicles.

All fuel cells work by combining hydrogen and oxygen in the presence of a catalyst and heat to form water. They are not subject to the second law of thermodynamics and thus can have efficiencies much higher than thermal engines. Single cell peak efficiencies over 60% have been demonstrated at moderate power levels. This is more than twice the peak efficiency of typical piston engines and 20% better than the best existing thermal engines (combined cycle gas turbines for utilities) which are not weight limited, operate near peak power most of the time and do not have to start or change power rapidly.

I am concerned that the problems of developing and commercializing fuel cells which are performance and cost competitive with existing engines - are under estimated - even if the competitive engines require costly environmental controls. My concerns include:

- The fact that fuel cells have been shown to be technically feasible can be misleading. It will take many years and a major commitment by industry, with government support, to reduce costs to an acceptable level for cars.
- There are at least five types of fuel cells, each of which has advocates which say theirs is the answer - for some vehicle applications.
- Private companies will not be able to justify investments in fuel cell research and development until there is enough information to prepare business plan which have a high probability of leading to profits.
    - The research and development costs are very high. If a private company were to commit to the development of a fuel cell, recovering its research and development costs could make the first production fuel cell propulsion systems prohibitively expensive - even if the manufacturing costs were attractive.

The five classes of fuel cells, Phosphoric Acid, Proton Exchange Membrane (or Solid Polymer), Solid Oxide, Molten Carbonate and Alkaline are at different stages of development. Most of the effort to date has been on Phosphoric Acid, Solid Oxide and Molten Carbonate for Stationary Power. The German navy has run a submarine on alkaline cells (and has or is planing to use Solid Polymer fuel cells). At this time the solid polymer fuel cell appears to be the most attractive in terms of compactness, efficiency, responsiveness etc. But - at this stage in the development of a new technology it is impossible to select the ultimate winner.

The names of the different fuel cells are derived from their electrolyte. They operate at different temperatures. Some of the higher temperature fuel cells can internally reform hydrocarbons - the lower temperature fuel

(Phosphoric Acid and Proton exchange) cells require a reformer or other device to reform a fuel (preferably methanol or natural gas) into hydrogen and carbon dioxide.

A number of demonstrations of fuel cell technologies in cars and buses are planned. These will help inform people who do not know what a fuel cell is or its potential. Some people do not like it - when I have called some these programs "stunts". We must be careful - the available fuel cells are only little better than bench test items. There is a high risk of failures. The failures probably will not be basic, but some detail like a bolt not properly fastened. I have seen support for innovative concepts disappear because it rained the day we demonstrated them.

I doubt if fuel cells, or other advanced propulsion systems, will be commercialized in the U.S. unless ways are found to subsidize, or write off, their research costs and address other non technical barriers.

Another way to reduce emissions from cars is to reduce their power requirements by reducing weight, aerodynamic drag, tire resistance and limiting accelerations. Progress in these areas is approaching the point of diminishing return.

Only weight reduction offers much further promise. The automobile manufacturers and suppliers are developing new light weight economical materials. Candidate materials exist - and are used in aircraft. The problem is that what is acceptable for aircraft may not work for automobiles. A major problem is manufacturing cycle time. When the manufacturing and cost problems are solved - and I am confident that they will - we may look at the ownership of cars in new ways.

There has been growing environmental concern over the disposal of cars and components when they have exhausted their useful life. This will continue to be a problem for tires, batteries and similar components, but a majority of the materials in cars (70% by one source) are now or can be recycled.

There may be an interesting result of the increasing life of cars. Maintaining environmental standards for 100,000 miles will require designs which will last even longer. Use of corrosion resistant materials which are less subject to damage or wear and new propulsion systems (such as fuel cells) may extend the life of cars to the point where people may have them upgraded or remanufactured, rather than purchase a new car. People may request changes in accommodations, appearance, and accessories to match their life style changes. This may be done in the dealers back service shops, which

might otherwise be under utilized as cars become more reliable. We may not need to dispose of nearly as many car carcasses as in the past.

I suspect that we could do about as much to reduce energy consumption (and pollution) by reducing the routing errors and delays by traffic signals and congestion on streets and expressways, as can be done - practically - with internal combustion engines. There are two basic approaches:

First	Tailoring cars to serve specific travel purposes.
Second	The use of intelligent vehicle - highway technologies.

Work is in process on what California calls "narrow lane" cars for commuting. Since in over 80% of the commuting trips the driver is the only occupant, well designed, economic, single (or one and a half) passenger cars may be attractive. One concept has an estimated fuel economy of over 120 miles per gallon.

In most cities over half the trips take less than 10 minutes. Most shopping trips take less than 5 minutes. Small cars which can serve these trips can be powered by conventional batteries. A Southern California Edison study estimated that the use of these cars, ("shoppers") for all trips under 8 miles, could reduce noxious emissions by 45 to 50%.

The use of "alternative" cars would permit people to continue their present life styles - and be environmentally responsible. If 20% of the commuting trips were made by "narrow lane" cars and a like number of trips to stores, transit stops etc were made by "shoppers", the use of petroleum in major cities would be reduced 15 to 20%. There should be even greater reductions in emissions. It is the short trips, before cars warm up, that are the most difficult to control.

Intelligent vehicle-highway technologies can reduce emissions and energy consumption by showing drivers the best route to new destinations, by reducing the frustrating delays at traffic signals when there is no other traffic and by reducing congestion. The benefits will be site specific, but some estimates have ranged up to a 20% reduction in emissions by implementing real time scheduling of traffic signals alone. This will reduce fuel waste during idling and accelerating as well as braking energy losses.

The "clean car" technologies can be used in other ground vehicles, including locomotives, buses, and heavy trucks. Use of public transit has been advocated to save energy and reduce pollution. But in fact diesel buses no longer do either, as a recent University of California Berkeley paper

shows. Rail transit is only slightly more energy efficient than the latest generation of automobiles. Public transit should be advocated for the important services it provides - not energy savings.

Fuel cells will probably be used first in buses. They should reduce the complaints about the emissions, noise and smell of diesel engines. The first economically competitive application is expected to be in locomotives, where their life cycle costs of the first generation of fuel cells may be less than the existing diesel powerplants.

Experience in these less cost sensitive applications should provide some of the "hands on" experience needed to develop a second generation of lower cost fuel cells which will be competitive with piston engines in automobiles.

The third question was *"What impediments if any, exist to the designing and producing clean cars? How can these impediments be overcome".*

Let me summarize some of the impediments which I have encountered sponsoring innovative technologies and transportation systems, which apply to the development of a new generation of automobiles.

- Foreign Competition
- Availability of Resources
- Inadvertent delays results of regulations
- Safety and product liability concerns
- The culture of the industry

The automobile industry, as a whole, has experienced major financial losses in the last few years. The primary (but not only) cause was foreign competition. The industry is rapidly correcting the reliability and design problems, but it will take years to recover the buyer loyalty which has been lost. It has to be more than just - as good as - the competition. To recover the market share the manufacturers must make major investments in new product designs and facilities.

A study by the University of Michigan estimated that the U.S. manufactures would have to spend $225 billion on new cars and trucks in the next four to five years to remain competitive. This is about three times the recent rate of expenditure. I doubt if the industry can develop these funds - without government support.

Foreign competitors are expected to spend $375 billion in the same period on products aimed at the U.S. market. The Japanese seem to make more effective use of the money they invest. By 1996 less than half of the automobile platforms which will be marketed in the U.S. will be produced by U.S. companies, down from 1991 when 70% were produced by U.S. manufacturers.

In addition to the investments to improve its products, the industry is committing a major share of its resources in what can be called "second best" solutions. It has no choice - it has to meet federal and state regulation time schedules. Money is not the only constraint. Relatively few engineers and designers have the background to work on advanced propulsion systems.

Engineers and scientists, who became redundant during the military cutbacks are a potential source of technical personnel. But, as I know from personal experience, the difference in the two cultures is so great that it takes years to make the cultural changes. The education of these scientists and engineers on automotive technology and culture will be a challenge for our academic institutions.

The scientists can contribute to our knowledge base. But, it is the engineers who make the automobile industry work. Nearly 10% of the graduate engineers in the Unites States live in the four counties adjacent to Detroit, but there are relatively few PHd's.

It is important to point out that the public image of the automobile is incomplete. About half of the value added in the industry and over half the people employed work in companies with less than 250 employees. 40% have less than 20 employees. These companies are the real strength of the industry. They provide specialty services including design of cars and trucks, the design and production of manufacturing equipment, robots and transfer lines as well as production of small components. I am more concerned about their survival than that of the big three.

Many federal and state regulations and laws were prepared on the implied assumption that there would be only minor "evolutionary" changes in transportation equipment and technologies. The "narrow lane" cars should be able to meet the intent of automotive safety regulations - but they may not be able to meet all the details. A simple illustration - there would be a problem if lights were required to be five feet apart. Regulations intended to insure the safe use of natural gas and propane in buildings, can slow, or prevent the use of new fuels and propulsion concepts. Even

when it is agreed that regulations should be changed, to permit use of a new technology or system concept, it may take longer to revise the regulations than design the product.

The government procedures for research and development contracts, which require periodic renegotiation, can cause major delays the development of new technologies. When companies have confidence that they can develop profitable products, many have found it less expensive and faster to fund the programs without government support. The problems they avoid include; the increased paper work required to document what is done, delays in getting approval for changes when new opportunities are identified, delays for periodic re-bidding and concern over intellectual property rights.

The governments share of research costs should reflect the level of risk and the problem of amortizing research and development cost. I believe that the governments share should be high at the beginning (say 80%) decreasing as confidence in the technical and economic feasibility of the product increases. The final product design and commercialization efforts should be privately funded. This would parallel the process followed by some of our international competitors.

The automobile industry places safety at the top of its priority list, but the growth of product liability litigation has made companies reluctant to introduce radically new concepts. New operating technologies will seldom be introduced until there is a safety record, which insurance companies can use. It may have to be developed in some other nation.

The "narrow lane" car is an example of the liability concerns. The developing company was considering marketing it in the late 1970's when its legal department pointed out that one accident could cost as much as the anticipated profit. Even if the "narrow lane" cars were safer - than all conventional cars - they are different and there would be accidents which would be blamed on its difference. The cooperative program with California would not have started if Caltrans legal had not suggested that it consider assuming the product liability during the demonstration. One engineer from a major company (not GM) told me, in frustration, that unless something was done about product liability, he doubts if his company would introduce any new technologies in this country.

An energy company contact has told me that their research on new means of storing and transporting hydrogen may have to be conducted overseas because O.S.H.A. bans the use of some of the intermediary chemicals which

they may have to use in producing test specimens of hydrogen transport materials.

I know that many people suspect that the culture of the automobile industry is one of the reasons for the industries reluctance to invest in new technologies. Not surprisingly some middle technical management who based their careers on the continued use and improvement of "conventional" concepts and technologies will resist change.

My experience is that this is not true of top management. It is true that most were not concerned about the threat of imported cars - until too late. Many of those that were concerned, underestimated the risk. Management is serious about trying to balance the market, energy and environmental imperatives, an at times inconsistent set of requirements.

What is also true, but may not be admitted officially by most companies (because they are either to polite, to proud, or concerned about being misunderstood) is that the industry feels that it has done its share. It believes that many of the things which are being suggested - by people without experience in the industry - are either impractical, unnecessary, counter productive or destructive.

- The industry understands why the public is interested in "clean cars" - but points out that no car is, or ever will be, completely clean. Experience shows that the cost of the strategies to control emissions increase exponentially as the allowable emissions decrease.
- The emission level has been reduced to the point that nearly one hundred new cars generate fewer noxious emissions than one 1966 car. Not totally facetiously - I hear automotive engineers claim that the exhaust of a ultra low emission vehicle (ULEV) would be cleaner than the ambient air in Los Angeles.
- Automobile marketers fear that technologies which increase cost, or reduce the utility, of cars will lead people to hold onto old cars longer. As a result emissions may not decrease as rapidly as would be possible with less costly approaches.
- Manufacturers are concerned that the combination of requirements, for low emissions and high mileage, will force them to build products which will not be saleable to most people. This could seriously damage the industry. Even without any changes in existing regulations, some industry observers are concerned about its survival - at least in this country - in its present form.
- One belief that industry spokes people will never state (except late at night after a couple of drinks) is that they suspect that some of

the regulations being advocated are not based on technical feasibility or health requirements, but a on belief that it is immoral to drive large cars - or some times any car. This contrasts with the automobile culture which holds that the mobility that the automobile provides is responsible for the high quality of life that recent generations have enjoyed.

Cooperation between the industry and government in the development of near "clean car" automotive and propulsion technologies will require a new approach and a willingness to understand each others problems and objectives. At times the two sectors do not even seem to hear each other - or even talk the same language.

The industries emphasis is on near term survival - meeting competition and legal mandates. This makes it difficult to justify diverting significant resources to the development of near "clean cars". It is unlikely that much will be done unless there are government initiatives, not only research and development funds (although that is critical) but for changes in laws and regulations which will make it possible to proceed expeditiously and draw effectively from all available resources.

What does industry need? Research support is only one element. I am not comfortable discussing the industries financial needs, but investment tax credits and caps on health costs (which now approach 40% of the wages for many small suppliers) are among the steps which have been suggested to make it easier for industry to devote additional resources to long range solutions. The problems the industry has in raising working capital and earning a profit, have lead some companies to sell off non automotive divisions which have provided them with a "window" on new technology.

The industries problems have already caused the failure of many small suppliers (foundation companies) which provide about half the value added and employ over half of the workers in the automobile industry. The majority of these companies employ fewer than 250 people. The specialty manufacturers, shops and design services represent a unique resource and one of the primary strengths of the U.S. automobile industry. We cannot afford to loose them.

Formation of consortia, or teams, has been suggested as one way to accelerate the development of near "clean cars". The teams would be made up of government laboratories and private companies, working toward common goals and benefits. The consortia would conduct all the research and demonstrations, including development of manufacturing processes, facili-

ties and marketing strategies to expedite the commercialization of near "clean cars". Competing consortia should work on different approaches. The charters of the consortia should enable them to avoid some of the procedural delays usually encountered in government contracting - as long as milestones are achieved.

This may surprise some readers, but I have reservations on the wisdom of joint research and development activities by the industry. I have no problem with cooperation on basic research, although this is the area where government investment will be most helpful.

My concern goes back to one of the roots of the complacent attitude the industry took to foreign competition. The U.S. automobile manufacturers all had similar labor costs, similar material costs, similar suppliers and what they thought was buyer loyalty. Their history of exploring a wide range of new ideas by their research and development activities (a luxury they can no longer afford) lead to a "not invented here" attitude. They had little reason to innovate. At least the separate research and development staffs did lead to some product differences.

If the companies all draw from the same research and technology base, we may inhibit technical and product innovation - just when it is most needed. We need to encourage competition to evaluate parallel technical and design paths. The path most obvious now - may not be the ultimate winner - or there may be more than one winner. Perhaps the best analogy is the military aircraft fly offs.

The final question which was asked is *" What is the potential export market for clean cars and clean car technology"*.

Of course there are international markets - but based on past experience we will probably only export the basic technology - and buy the developed products from other nations.

A final note. I do not see the "clean car" initiative as concluding with a futuristic family sedan with exceptional emission characteristics or by setting specific environmental objectives for future products. I see it leading to the creation of a process for determining how to continue to reduce emissions as new technologies are developed. Creating incentives for innovation not mandates. We do not know what technologies will be developed in the future, or for that matter of fact what approach is best now.

The governments primary role would be in sharing the risks during initial research on new technologies and demonstrations until product acceptance (price, performance, profitability) is not in doubt. The "clean car" process should provide information for setting time schedules which do not require industry to use "second best" solutions, or hurry products to the market before they are ready. After this process has been in effect for a period of years, the resultant emission levels should be much lower than now expected, or possible with existing technology.

This version of the testimony prepared April 28, 1993. It includes changes based on comments and discussions at the hearing.

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An environmentally friendly "green" car is possible, using conventional gasoline-powered vehicles manufactured today, with a minimum of modification. Blue Planet Technologies Co. LP has developed a three-way catalytic converter which can be installed on present-day cars and exceed 1994 model year Federal EPA and State of California standards and which is contemplated, will exceed 2003 model year standards within the next twelve (12) months.

The Blue Planet technology is based on a fundamentally new concept: heterogeneous three-way catalysis by metals deposited from exhaust gases on a prepared muffler packing. Three-way catalysis as practiced by Blue Planet is initiated by gas phase metal deposition and utilizes proprietary development of four technologies: a) heterogeneous three-way catalysis; b) steel as a construction material in hostile environment - particularly, use of metallic substrate in an automotive catalytic converter; c) surface development from gas phase deposition; and d) use of fuel additives to meet particular technical needs.

Distinctive features of the Blue Planet technology are:

1) Blue Planet three-way catalytic technology is exceptionally efficient in controlling NO_x.

2) Catalytic converter is an intrinsic part (packing) of the muffler system. No need for a separate catalytic converter within the exhaust system.

3) Catalytic substrate is metallic, particularly made of steel which brings all the advantages of metallic substrates.

4) In principle, there is no need for a special and separate washcoat. Currently, a sufficiently developed surface of the catalytic substrate is obtained by simple treatment resulting in oxidation of the steel surface (e.g. Fe_xO_y). This process is particularly easy for low carbon steels and entirely functional for stainless steels. Moreover, the process is considerably less expensive than that used today for conventional substrates.

5) Catalytic metals are delivered into the combustion chamber. The metals are then deposited on an oxidized substrate from exhaust gases and continuously form catalytic sites. No need for prefabricated (elaborate) catalytic surfaces.

6) The source of catalytic metals is fuel additives that are directly dissolved in gasoline. No need for special solvents and other extraneous agents, which may be detrimental to the combustion process, or to the resultant emission quality, or both.

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7) Variations in exhaust gas flow have no discernible effect on the efficiency of the Blue Planet three-way catalysis. Our technology produces optimum catalytic performance throughout varying combustion regimens and flows. New gas flow speeds and paths are continually adopted to during the extended use of the Blue Planet catalytic vessel.

8) Blue Planet technology virtually eliminates metal emissions to the atmosphere. The added metals are mostly trapped - an intrinsic effect of their catalytic performance. This alleviates a major problem of fuel additive use: metal emission to the environment.

9) In principle, any metal of catalytic importance can be introduced into the catalytic system. Currently, the metals are both noble: Pt, Rh, Pd & Au; and non-noble, Re. Consumption of Pt & Rh is comparable to and potentially more efficient than conventional TWC consumption.

10) The catalytic additives may at the same time improve fuel combustion (a fringe benefit). Data are available as to the effect of these metals at comparable concentrations for gasoline and diesel engines.

11) The Blue Planet technology simplifies and reduces costs of current three-way catalytic manufacturing programs, particularly of expensive and energy-intensive processes such as: preparation of a substrate, noble metal impregnation and activation.

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Written Statement

of the

Electric Transportation Coalition

before the
Subcommittee on Clean Air & Nuclear Regulation
Committee on Environment and Public Works
U.S. Senate

May 13, 1993

Introduction

This statement is presented on behalf of the Electric Transportation Coalition (Coalition), a nonprofit organization of electric utilities, automobile manufacturers, state and local governments, and other public and private groups that have joined together to advocate the greater use of electricity as a transportation fuel. (A list of the current membership of the Coalition is attached and submitted for the hearing record.) As one of its major objectives, the Coalition seeks to encourage the adoption of incentive-based policies and programs -- at all levels of government -- that are designed to support the commercialization and widespread use of electric vehicles (EVs) and supporting infrastructure in the United States.

These comments address first the need for, and benefit of, electric vehicles in the United States. Second, the statement describes already adopted federal programs designed to provide nationwide incentives for electric vehicle commercialization and infrastructure development. And finally, a set of incentives (regulatory and legislative) that the Coalition is recommending to states for consideration and possible implementation is described.

Why Encourage Electric Vehicles?

The U.S. transportation sector today accounts for nearly two-thirds of all the oil used in this country. Although the fuel economy of the new car fleet has more than doubled since 1974, U.S. petroleum consumption in 1989 was about the same as in 1974; a result of increases in both the numbers of vehicles on the roads and the number of vehicle miles traveled each year. Electric vehicles present our nation with a very important means to reduce our dependency on foreign petroleum and to increase the diversity of fuels used in the transportation sector. EVs are powered by abundant, domestically-produced energy generated from a variety of sources. The U.S. Department of Energy (USDOE) has reported that, on a nationwide basis, electric generating capacity is available today and sufficient to recharge millions of electric vehicles. Also, the USDOE has calculated that if approximately 22 percent of the total number of vehicles in the United States were replaced with EVs and electric hybrid vehicles, nearly one million barrels of oil, per day, could be saved.

Electric vehicles, which are truly "zero emission" vehicles, could reduce significantly emissions from the transportation sector. These vehicles produce no tailpipe emissions and generate insignificant emissions resulting from operation (such as emissions from braking). Unlike other vehicles, EVs are not subject to emissions system deterioration over time, and there is no danger of tampering or disabling emission controls. In fact, the only identifiable emissions attributable to electric vehicles are those associated with the generation of the power needed to charge electric vehicle batteries. And powerplant emissions are subject to rigorous environmental controls.

For urban areas especially, the use of EVs would contribute to substantial reductions in emissions of those mobile source pollutants, including volatile organic

compounds (or VOCs) and oxides of nitrogen, that are the precursors of urban smog. This environmental benefit is of utmost importance in states, like California, where a vast number of residents live in areas which fail to meet minimum federal air quality standards.

Finally, electric vehicles and associated technology development and commercialization can provide economic development opportunities for the nation. The Critical Dual-Use Technology Panel, established by the Congress, has designated electric vehicle technology as one of twenty-two technologies critical to the U.S. in terms of national security, health, economic security and the environment. Development of an electric vehicle industry might assist in mitigating the economic hardship and worker displacement that is occurring in the U.S. due to the draw-down in defense spending. The electronics and aerospace industries are particularly well suited to play a significant role in developing the componentry and materials required for electric vehicles.

Specific Federal EV Incentive Programs

The environmental, energy security and potential economic development benefits of electric vehicles cannot be realized until there is --

- commercial production of road-worthy EVs;
- consumer acceptance/willingness to purchase such vehicles; and
- the infrastructure in place that is necessary to support EV usage.

Current Activity and Required Incentives for Technology Enhancement

All three major U.S. automobile manufacturers (OEMs) have established EV programs and are projecting the commercial availability of road-worthy EVs by the late 1990s. General Motors is developing a "ground up" two-seater electric vehicle (called the "Impact") and is expected to begin demonstration of 50 Impact prototypes this year. Ford will produce 87 electric and/or hybrid electric "Ecostars", beginning this year, for demonstration in the U.S., Europe and Mexico. The Ecostar is an electrified version of Ford's Escort delivery van that is widely used today in Europe. Finally, Chrysler has announced that it has sold 50 of its model year 1993 electric mini-van, known as the "TEVan", and is accepting orders for model year 1994. The TEVan is an electrified version of its popular Caravan/Voyager model.

While the major U.S. automakers have aggressive EV development programs underway key technical issues remain. In order to address some of these issues the federal government is pursuing a number of joint R&D programs with industry.

Current Federally-supported EV research and development activities include a cooperative effort with the U.S. automobile and utility industries to support the

development of advanced batteries. The Federal government intends to contribute as much as 50 percent of the funding to this $260 million cooperative effort, known as the U.S. Advanced Battery Consortium (USABC). The Administration's budget request for fiscal year 1994 includes a recommendation for $40.7 million in funding to the Department of Energy to continue the government's role in the USABC.

The Electric Transportation Coalition supported the inclusion of provisions in the Energy Policy Act of 1992 (EPAct) to address other needed research and development in electric vehicle and related technologies. Specifically, the EPAct, under the leadership of Chairman Brown and other Members of this Committee, authorizes a multi-year (FY 1993-1998), $485 million research and development program for electric motor vehicles and associated equipment. The legislation provides additional authority to the DOE to conduct EV programs. Also, authority is provided to undertake R&D into areas such as fuel cells for transportation applications, high efficiency electric power trains, lightweight structures, photovoltaics for use with EVs and hybrid power trains.

Importantly, the Act seeks to create a greater role for industry in defining research priorities and participating in R&D activities. This is accomplished by a requirement that R&D be carried out through cooperative agreements with industry, which will generally require that non-Federal partners provide 50% of research project costs. The Federal share of the cooperative research projects is subject to appropriations being made. Assuming that appropriations are available, DOE is required to solicit proposals for research and development projects by October, 1993. To help define this multi-year R&D program, DOE is required to prepare a comprehensive five year plan. That plan was due in April, 1993. While the Department has yet to comply with this statutory requirement, the Coalition is hopeful that the multi-year program plan will be forthcoming in the near future.

Incentives to Develop Market Introduction of EVs

Customers are often wary of new technology, and the segment of the market that wants to be "first on the block" with the latest new product is likely to be small. The electric vehicle may well be viewed as a radical departure from the traditional vehicle, even if the function of the vehicle is quite similar to that of an internal combustion engine system.

Assuring early markets for EVs will require that consumers have greater access to and familiarity with newly emerging EV technologies. This is an area where incentive programs could have a major positive impact.

To address this market development issue the EPAct authorizes a 10 year, $50 million electric vehicle demonstration program to accelerate development and use of EVs and to evaluate operational performance of EVs and needs for supporting infrastructure. Through a competitive program, DOE would provide funding to at least one, but no more than 10, proposed programs to demonstrate EVs. EV programs selected for funding, based on criteria specified in the Act, will be sited in metropolitan

areas, and must involve at least 50 vehicles. Federal financial assistance would be utilized to support the cost of EVs to purchasers, with the maximum discount, or support, per vehicle limited to $10,000.00.

As with the EV research and development program, implementation of the commercial demonstration program will require the appropriation of federal funds. Assuming that funds become available, DOE is required to issue a solicitation for participation in the program by April, 1994. The Administration has requested very modest funding to initiate the EV commercial demonstration program authorized under EPAct. The Coalition does not believe that the level of funding requested for FY 1994, $3.736 million to be utilized for **both** the EV commercial demonstration program and the infrastructure development program discussed below, is sufficient to assure that these programs can be initiated during fiscal year 1994.

Incentives for EV Infrastructure Development

The EV operator must have the assurance that the infrastructure to support the operation, maintenance and servicing of EVs is in place when the transition to electric vehicles is made. The term "infrastructure", when used in connection with EVs is broadly defined, ranging from techniques and equipment used to recharge the EV to servicing and maintenance training for mechanics to development of safety protocols for rescue personnel responding to accidents involving EVs.

Again, the federal government, through the Energy Policy Act, has committed to support and complement the efforts currently underway by the automobile and utility industries as well as various state governments to develop and "put in place" these important infrastructure support systems.

EPAct authorizes a 10 year, $40 million government/private industry cooperative program to research, develop and demonstrate EV infrastructure. Fleet operators, utilities and others will be eligible to compete for financial assistance, which would be made available by DOE, for up to 10 projects. Projects eligible for funding could address the servicing of EVs; installation of charging facilities; rates and cost recovery for electric utility investments in EV infrastructure; health and safety procedures; information dissemination efforts or other programs. Non-federal sources will be asked to provide at least 50% of the overall program costs and no one project will be eligible for more than $4 million in federal funding.

As with the other new programs authorized under the Act, appropriations are required to implement the infrastructure program. And, as discussed above, the Clinton Administration's FY 1994 request for funding to this program is not deemed adequate.

Tax Incentives

The response of the marketplace will be hindered greatly if the initial price of electric vehicles is far out of proportion with the price of comparable, gasoline-powered

vehicles. Early EVs are expected to be more costly than comparable vehicles, due, in part, to the entirely new technologies involved and the lack of mass production/economies of scale. Mandatory programs do not solve, or even necessarily address, this critical cost issue. That is why, from the standpoint of the potential customer, the most effective programs may well be addressed to the bottom line: the price for acquiring and operating an electric vehicle.

The Energy Policy Act put in place an extremely important federal tax credit for the purchaser of an EV, and a tax deduction for investments made in clean fuel refueling property. The Act creates a tax credit for business and individual purchases of electric vehicles equal to 10% of the cost of an EV, up to $4000.00 per vehicle. The credit is available for property placed in service after June 30, 1993 and will gradually be phased out after the year 2001.

The Act also created a tax deduction for alternative fuel refueling property, including property used in recharging electric vehicles. A deduction of up to $100,000.00 per refueling site will be available to businesses for property placed into service after June 30, 1993 and before December 31, 2004. While this deduction is significant for other alternative fuels, it is not so significant for the initial phases of EV introduction because much of the "re-fueling" of electric vehicles can be accomplished through relatively inexpensive, at-home hook-ups.

Summary of Need for Incentives

All of the incentives described above are vitally important to assure that this important new mode of transportation is developed and successfully introduced into the market. Today, only the federal tax incentives can be used. The demonstration programs authorized by the EPAct must be appropriated. The Coalition believes that only by fully implementing all of these incentives can we be assured the development of this new technology and the encouragement to initial purchasers to make the investments necessary to create a self-sustaining EV market for the future.

Economic Growth/Defense Conversion Incentives for EVs

Defense-Related EV Funding

Efforts to rebuild national infrastructure and create jobs are fully compatible with efforts to encourage the commercialization of electric vehicles and related infrastructure. An initial activity to support these national objectives of infrastructure development and jobs creation was undertaken last year through a $25 million appropriation to the Advanced Research Projects Agency (ARPA) to conduct a cost-shared EV/Infrastructure demonstration program with the private sector. ARPA has issued a "Research Announcement" inviting proposals by regional consortia from around the country to further advance EV-related technologies for both military and civilian utilization.

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Industry must submit project proposals under the program by June 11, 1993 and project selections are expected to be made by ARPA by September 6, 1993.

In addition to the ARPA program specifically directed at EV/Infrastructure demonstration, EV-related technology projects, proposed by industry, will be eligible for funding under the $470 million "Technology Reinvestment Program" being administered by ARPA.

Department of Transportation Funding

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) reauthorized Federal surface transportation programs and created new flexibility in using funds for transportation projects. ISTEA created two programs of particular significance for EVs.

The Federal Transit Administration (FTA) established a $12 million program for research into EVs and advanced transportation systems which is providing federal funding to four consortia around the country. While the bill provided only $12 million in federal funding to this innovative program, some members of Congress are seeking additional funding to the program in fiscal year 1994.

ISTEA also authorized a $6 billion, 6-year congestion mitigation and air quality improvement (CMAQ) program through which States may utilize funds from the Highway Trust Fund for transportation-related projects in non-attainment areas with air quality and vehicle congestion problems. A variety of projects, which could potentially involve EVs, are eligible for funding, including projects to implement transportation control measures under the Clean Air Act, projects included in State Implementation Plans under the Clean Air Act, and other projects receiving Federal approval that will contribute to the attainment of national ambient air quality standards.

State Programs and Policies to Complement/Enhance Federal Efforts

The Coalition members believe strongly that state governments, along with the federal government and private industry, have a critical role to play in assuring the development of a self-sustaining EV market.

For this reason, the Coalition has developed and is advocating adoption of a package of state-level incentives particularly tailored to address three interrelated issues that will influence the successful commercial deployment of EVs: market development, infrastructure support and technology enhancement.

Attached to this statement is an outline of the concepts included in the state "Model EV Legislation" being advanced by the Coalition. The concepts advocated by the Coalition include: tax incentives directed toward consumers and manufacturers; creation of programs and policies to encourage the creation of the infrastructure necessary to

support widespread use of EVs within the state; and general state programs to stimulate an appropriate market response to introduction of EVs.

Many of the concepts advocated by the Coalition are already under consideration by a host of states. Also attached to the statement is a listing of enacted, pending and potential state laws that would impact EV commercialization and use.

We are greatly encouraged by states' recognition of the importance of providing incentives -- directed at the consumer, manufacturers and fuel suppliers. Industry, working in concert with government at all levels, can develop a viable, sustainable market for electric vehicles in the United States by the turn of the century.

Conclusion

The efforts to support EV development that are underway by the federal government can provide crucial assistance. However, unless the EV programs established under EPAct are quickly and adequately funded and implemented (and important, on-going programs like the USABC continue to receive sufficient federal funding), momentum in the "race" to bring a road-worthy electric vehicle to market could be lost.

The Coalition appreciates this opportunity to comment on the need for, and benefit of, federal incentives to encourage EV and related infrastructure development. And, the Coalition looks forward to working closely with the Subcommittee on EV-related issues and legislation that may be considered during the 103rd Congress.

NOTE: THE ATTACHMENTS TO THIS STATEMENT HAVE BEEN RETEINED IN COMMITTEE FILES.

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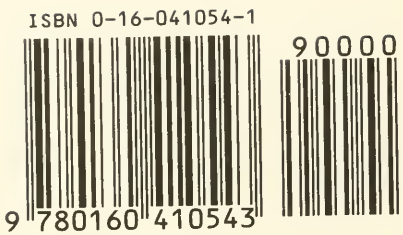
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